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***The* SCIENCE  
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### Blood — A Circulating . . .

By Eric Ellenbogen, School of Public Health, University of Pittsburgh, Pittsburgh, Penna.

### The Occurrence of the Common Elements

By L. M. Foster, Alcoa Research Laboratories, New Kensington, Penna.

### The Story of Veterinary Medicine

By Kenneth B. Haas and J. Lavare Davidson, Veterinary Medical Department, The Upjohn Company, Kalamazoo, Michigan.

### Correlation of Art With High School Biology

By Sister Mary Maurice, Mount Mercy College, Pittsburgh, Penna.

### What Does Industry Expect of Technically Trained Graduates?

By R. H. Scheldt, Personnel Division, Employee Relations Department, E. I. Du Pont de Nemours and Company, Inc., Wilmington, Del.

### The Keystone Visual — Survey Service

By G. E. Hamilton, M. A. Oxon., Member Pennsylvania Council of Education.

### The Romance of Tobacco Mosaic Virus and the Electron Microscope

By Robert V. Rice, Head, Division of Electron Microscopy, Department of Research in Chemical Physics, Mellon Institute, Pittsburgh, Penna.

### The Science Seminar, An Integrating Tool

By Sister Denise Eby, M. S., Associate Professor of Chemistry, St. Joseph's College, Emmitsburg, Maryland.

# More Dynamic Botany

• By **Marie Clark Taylor, Ph.D.**, (Fordham University)

ASSOCIATE PROFESSOR OF BOTANY, HOWARD UNIVERSITY, WASHINGTON, D. C.

*Teachers of botany frequently overlook the significances of the plants within the students' immediate environment.*

*The principles of plant science can be made more interesting to the student if they are explained using plants with which the student is already familiar.*

The objectives of introductory botany are embodied in those of all the biological sciences in general education. Students who are aware of the ubiquity, diversity and simplicity of plant forms are cognizant of the action of environmental factors upon the inherited features of the basic activities of all forms of life. Familiarity with the physiology of plants gives an understanding of the complex and intricate interplay of physical factors without and within the bodies of all organisms, and of the biochemical interdependencies of microorganisms, autophytes and animal forms. The study of the history of plant science, which constitutes a large part of the general botany course, gives an understanding of the importance of plants to civilization, to fundamental research into living matter and its activities, while providing an insight into the methods, attitudes and achievements possible through familiarity with investigative reasoning. These are goals of general education that are attainable in botany courses organized around basic principles of plant science.

Despite the intellectual and cultural values which may result from the development of skills in observation, manipulation of instruments, and the tracing of the classic experiments of great botanists, botany seems unattractive to a great number of students, majoring in other areas of knowledge than biology. Yet the survival and increase of botany classes is predicated upon the unique contributions of this science. Is it possible to make them more manifest?

A recent survey of the needs for botanical information, made by the members of a general botany class in Washington, D. C., revealed that most persons, especially home-makers, desired a practical knowledge of plants because they maintained plants about their homes. Accordingly, it may be surmised that every high school and college graduate, since he is a potential home-owner, needs plant science. Plant science, on the other hand, needs to become more attractive. The first course should encourage knowledge and skills in the wise usage, culture and control of the plants of the local community. For most schools this suggests greater familiarity with the horticultural plants for the lawn, garden and indoor ornamentation.

That this is a significant objective can be attested to by most instructors of botany or biology, since they are besieged with queries of horticultural or practical import. Students, even in their first courses, are also considered possible sources of advice upon the care of cultivated plants. And while the mastery of the principles of plant science enables one to apply theory to related conditions, classical botanical studies are made with few of the "problem" plants—lawn grasses, shrubs, succulents or house plants.

Any instructor can devise methods by which the generalizations of the science may be related to the plants of the locality. One of the easier methods of achieving this objective is to add the viewpoint of the consumer to the more prevalent one of increased crop production. As spectacular as is the increase in volume of certain agricultural plants due to the painstaking efforts of botanists in breeding, and precise control of light intensity, light duration, water, minerals and other environmental factors, few liberal arts students will utilize the techniques which made it possible. A general knowledge of the methods is valuable in comprehending the dependence of the consumer upon plant research.

More directly useful to students is the comprehension of the ways in which the factors of the environment may cause chemical and physiological changes in the form and condition of the plant products, plant organs, and the complete plants that constitute so large a part of his home. A knowledge of the chemistry and physics of the microscopic as well as the more obvious forms of plant life relates directly to family and community health, nutrition, and hygiene. Since the efficient utilization of plants eliminates waste or converts it into resources, theoretical botany with the plant species of the community demonstrates economy in effort, time and money.

The presentation of the numerous aspects of the domestic practicability of various taxonomic and ecological groups of plants within the unit framework of the course seems highly desirable. For example, the unit upon ecology is more easily embraced when "the environment" is immediate, and includes such problems as the nitrogen cycle in our city parks, the difference in the succession upon well-kept lawns and untended lots, or the characteristics of the most successful local species. Field observations of campus, lots, lawns, gardens and parks provide opportunities to acquire an acquaintance with not only cultivated plants and weeds, but also the significance of taxonomic categories such as families, genera, species, and varieties; the differences between adaptations and fluctuations; and the indices of optimal health in plants versus symptoms of deficiencies, malfunctionings or pathogens. Community

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## Boyce Thompson Institute For Plant Research

• By D. R. Ackerson

CARBIDE AND CARBON CHEMICALS COMPANY, A DIVISION OF UNION CARBIDE AND CARBON CORPORATION

*Population growth demands an increase in the productivity of agriculture.*

*Many new agricultural chemicals have been developed in recent years but, before a new insecticide, fungicide or herbicide can be put to use, its effectiveness and safety to humans must be firmly established.*

*The Boyce Thompson Institute, a non-profit institute, uses the combined skills of specialists in many sciences to solve the problems of agriculture.*

Every hour of every day there are about 3,300 more mouths to feed in the world. Every night three-quarters of the world's population goes to bed hungry. And, each year insects, plant diseases and other pests cost \$13-billion in crop losses in stored products. The building of houses and roads destroyed over one million acres of crop land in the last ten years. To add to this staggering set of statistics, the land available for farming is dwindling because of erosion and normal depletion of natural elements.

Much of the discontent in the backward areas of the world has its root in hunger. Much of the disease is caused by malnutrition and many of our retarded areas would be developed more quickly if the people had enough energy to do other things besides struggle for food.

Here then is the challenge to our plant scientists. Theirs is the task of finding ways to raise enough food to adequately feed the world and to keep at least apace with the rising world population. This is not a job that can be done by one lone scientist working in a small laboratory. It requires planning, a completely equipped place to work, and the best in cooperation between state, private, and commercial interests.

One of the places here in the United States where such a scientific atmosphere has been created is Boyce Thompson Institute for Plant Research in Yonkers, New York. Many of the achievements of the scientists working here have materially helped solve our agricultural problems. All of this started because one man had the foresight to do something about the way he thought the world was heading. Here is what he did.

In 1924, William Boyce Thompson founded Boyce Thompson Institute for Plant Research as a non-profit membership corporation in the State of New York. The Institute today is financed primarily from income derived from an endowment established by

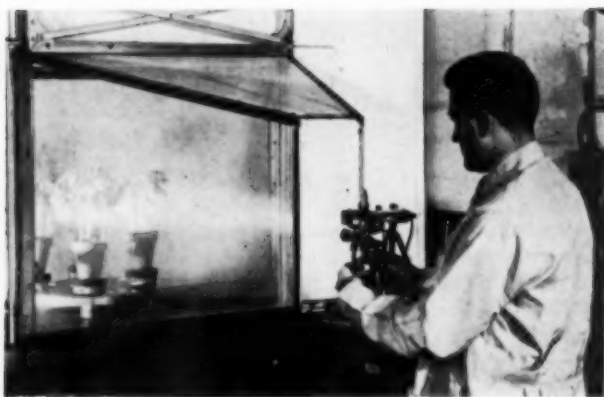
the founder. Other funds are obtained in the form of grants by private donors, the federal government, industry, and various associations, which support fellowships conducting research of interest to the donor. It was early agreed that the Institute's contribution would be of greatest value if three main principles were carried out. (1) to secure the best equipment possible for studying every phase of plant growth, (2) to assemble a staff representing the many techniques required in the study of plants, and (3) to attack problems in a fundamental way so that the results might contribute both to practice and to science. At the Institute, the pure research of science and the applied research of agriculture and commerce are not considered as contrasting elements in a scientist's obligation to society, but as normal extensions of each other. The scientists enjoy freedom in seeking each other's counsel and entering into cooperative projects, unhampered by any restrictive influence of professional departments. Few, if any, of our modern research projects can be prosecuted fully without encroaching into and drawing upon the best knowledge and techniques in different scientific fields.

In order to provide all the skills necessary for a research project, staff members trained in plant physiology, plant pathology, entomology, genetics, morphology, and chemistry have been assembled in a park-like setting in Yonkers, New York.

One of the companies which supports an extensive fellowship at Boyce Thompson Institute is Carbide and Carbon Chemicals Company, a Division of Union Carbide and Carbon Corporation. These fellowships are largely concerned with the discovery and testing of new organic chemicals for use in combating plant diseases, weeds and insects. Today, Carbide's men at Boyce Thompson receive hundreds of chemicals per year from other groups in the Corporation, most of them from the Carbide laboratories at South Charleston,

BOYCE THOMPSON INSTITUTE for Plant Research Inc., Yonkers, New York.





ONE OF THE MANY PIECES of testing equipment at Boyce Thompson Institute is this spray chamber used for testing fungicides.

W. Va., and the laboratory of the related Linde Air Products Company at Tonawanda, New York. Their job is to determine the usefulness of these chemicals and seek methods of improving them. Most of those found satisfactory are sold under Carbide's CRAG brand. Perhaps we can better understand how the Institute operates if we look at how the Carbide and Carbon Chemicals Company fellowship operates and what its work is accomplishing for the betterment of mankind.

On this fellowship, twenty-nine agricultural specialists are busy breaking all the rules of farming. They plow their fields, plant crops, and wait until the plants are a few weeks old—then plow them under to make room for more. They deliberately breed insects, tend them carefully, even controlling the temperature of the room in which they live—then see how many they can kill by shooting them with bug sprays. And they take hundreds of perfectly healthy plants, and deliberately infect them with plant disease.

For an ordinary farmer these goings-on sound like a sure way to starve, but, as a matter of fact, the activities of these men have brought about substantial increases in the production of food.

Fungicides are probably the least familiar of the agricultural chemicals. Home gardeners do not often recognize fungus attack as a serious threat, but farmers know that a fungus attack can turn a healthy field into rows of withered stalks in a few days. One authority estimates that over a 20-year period in the United States, fungus damage cost apple growers alone over \$10,000,000 per year.

Plant scientists at Boyce Thompson grow a variety of fungi to use as guinea pigs, on which to test fungicides. These fungi are bred in specially constructed, insulated rooms where the atmosphere and temperatures are controlled to be certain that nothing interferes with the cultures' growth. The fungi are grown in dozens of test tubes and jars, all tightly covered, to prevent different varieties of spores from traveling from one culture to another. This precaution is necessary because the fungus spores are so small and light that they are easily carried by the slightest movement of air.

EIGHTY

In their search for weapons against fungi, the scientists at Boyce Thompson test chemicals wholesale. In one test they first put a sample of two different fungi on separate glass slides and add a known amount of the new chemical to each. The slides are then put away for 24 hours, after which they are examined under a microscope, so that spores—living and dead—can be counted.

Chemicals that show a high rate of kill on this test are then given a trial on living plants. To do this, potted tomato plants are sprayed with a solution of the chemical mixed with water. Other plants are left untreated. Next, one treated and one untreated plant are sprayed with the fungus that produces early blight; and the other two are sprayed with late blight. Early and late blight are used because they are typical, common fungus diseases. All four plants are then placed in a warm, humid "tropical" chamber for 24 hours.

Substances that looked effective under the microscope may now show defects, in any one of many ways. For instance, they may prove to be less potent than originally thought; or they may wash off in the rain, instead of sticking to the leaves to give lasting protection. Or, even if a chemical is effective against fungus, it may be too active—against the tomatoes—with the result that the treated plants are not as healthy as the "unprotected" ones.

Initial failure doesn't mean that the chemical is useless. New experiments may be run to see what effect



FLIES USED IN THE TESTING of a new insecticide are raised under carefully controlled conditions.



MANY CAREFULLY CONTROLLED TESTS must be carried out before an agricultural chemical can be used by the farmers.

certain changes will have, like increasing or decreasing the concentration, or mixing the chemical with a "sticker" that will make it stick better.

Fungicides that pass these preliminary tests get further tests in the greenhouse, in the field, and at Mellon Institute, where extensive toxicological tests are conducted by Carbide's Industrial Hygiene Fellowship to make sure that the chemical is safe to handle. If these results are satisfactory, the fungicide is tested at agricultural experiment stations all over the country, under virtually all types of growing conditions. Tests are simultaneously made to see if any residues remain on edible crops and if so, that means more toxicological work at Mellon to be sure they are safe to eat in infinitesimal quantities over the human life-span. Efficiency data and residue and toxicity data then go to the Federal Government for clearance under laws and regulations that are too complicated to detail here. When all of these hurdles have been passed, and final adjustments made in concentration and rate of application, the product can finally be sold—but at first, usually only on an experimental basis to farmers who try it, and report on results.

The final step is full commercial production and sale.

Another Carbide group at Boyce Thompson working to get the "bugs" out of agriculture—literally and figuratively—is the group testing and developing insecticides.

One of the devices they use in their tests is a Peet-Grady Chamber, a room measuring 6 feet in each direction and lined with stainless steel. Built into its walls are observation windows, a tightly fitting door, and eight small holes with removable plugs. During a test, researchers put a number of flies, usually about five hundred, into the chamber. The flies, incidentally, are carefully bred to make sure that the same kind of insect is used in every test. Next a given amount of insecticide is sprayed through the port holes in each side of the chamber.

As researchers watch through the windows, they note the quick burst of rapid buzzing. Then the insects begin to falter, flying erratic jagged courses from wall to wall. After a few minutes they begin to fall to the floor, and finally lie still. Throughout the test, researchers note the time required for action, the number of flies killed, the number knocked out of the air, and other factors.

Good fly killers contribute more to agriculture than the layman might think. Not only are flies pests, and carriers of disease, but one authority estimates that the energy used by a steer to brush off flies, is enough to cut the steer's beef production by about 300 pounds per year!

Some less familiar insect pests are also having their life expectancy shortened at Boyce Thompson. These include many of the leaf-eating kind that destroy plants in your home garden. Leaf-eating insects are often combated by spraying the foliage with insecticides that stick to the leaves. Then, when worms or beetles start munching on the leaves, they find their dinners seasoned with a generous dash of poison.

One of these foliage insecticides has been tested at Boyce Thompson for use against "red spiders." These tiny creatures are permitted to feed on a bean plant, which has been sprayed. Then, because the insects are very small, they must be counted under the microscope to see what percentage has been killed.

Another one of the insecticides on which some work has been done at Boyce Thompson, is allethrin, a synthetic pyrethrin, which was developed to commercial production at Carbide's South Charleston research center. Pyrethrin has been used in insecticides for years because it acts rapidly and has, in the language of the specialist, "a fast knock-down effect." Before allethrin was synthesized, the only way to get this effect was to extract pyrethrin from the flowers of the pyrethrum plant. During World War II, airplanes plied between the United States and Africa, where the flowers are grown, carrying the dried pyrethrum flowers. These were made into insecticides for our troops to use against disease-carrying insects everywhere.

Herbicides, the third type of chemical on which work is done at Boyce Thompson, are more commonly known as "weed killers" or "weed preventers." Home owners use them to keep weeds out of their lawns. Golf-course fairways are often treated with herbicides to keep them free of weeds. However, these are only minor uses, because herbicides have tremendous use in agricultural applications. The time may come when no farmer will have to spend days of back-breaking work to keep his fields free of weeds. Instead, he will mix a little powder with a lot of water, and ride along on a tractor, spraying the area with a herbicide.

Herbicides might be called "educated chemicals," because they are often "selective" in being able to pick out and kill only undesirable weeds, while leaving the desirable plants alive. Although some herbicides are designed to kill weeds and leave grass healthy, others

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## Developmental Lenses for Children

• By **Richard J. Apell, O.D.**

GESELL INSTITUTE OF CHILD DEVELOPMENT, NEW HAVEN, CONNECTICUT

*Do our school health programs adequately provide for the correction and prevention of children's visual disorders?*

*Doctor Apell discusses a relatively new concept in the treatment of children's vision.*

The concept of developmental glasses for children, that is, glasses for temporary protection of the child's eyes from specific stresses, is relatively new in the field of optometry. Until a decade ago lenses were rarely used except to correct such measurable defects in the eyes as myopia, hyperopia, or astigmatism, or to compensate for the loss of ability to focus the eyes at near distances after the age of forty (presbyopia). The idea that glasses could be beneficial to some children and young adults who possessed 20/20 visual acuity in each eye, binocular vision, and no ocular pathology was novel indeed, for these individuals by all previous standards would be classed as having perfect vision.

Until recently the practice within the optometric profession was oriented toward correction rather than prevention or protection of visual problems. One result of this earlier orientation can be described by an example. Of the many children who started school with apparently healthy vision, some often showed the beginnings of myopia (nearsightedness) by the end of first grade or the beginning of second grade. Usually it was another six months or a year before a routine test with an "eye chart" (Snellen letters at twenty feet) picked up the difficulty. Since the child then showed a measurable nearsightedness, compensating glasses were supplied that "corrected" the nearsightedness and allowed the child to see the chalkboard and other distant objects clearly. The effect that such glasses had on reading and all activities within arm's reach was ignored. Rather than benefiting the child's near vision, they only disturbed it. They over-stimulated the focussing function, and this, coupled with the child's habit of reading at too near a distance and for too long a time, led to an increase in nearsightedness. The myopia became progressive. By now the child was destined to wear glasses for most of his waking days, and was forever eliminated from occupations where good distance vision without correcting glasses was required. Such was the typical use of compensating glasses in the case of the myopic child. Since many myopes are good achievers in the classroom, the situation did not present itself as a direct problem to the educator.

How do children with visual immaturities meet the nearpoint visual demands that the early school grades

put upon them? The myopic child already mentioned maintains satisfactory vision within arm's reach but gives up clear distance vision. But not all children are able to become myopic. One kind of child, finding it difficult to sustain on nearby visual tasks, may withdraw from the situation. He may become the class daydreamer, always staring out of the window. Another type of child may strive to meet the demands at all costs, but when asked how well he sees he will report that he can read for only 10 minutes or so before his vision blurs and he has to rest and then return for another ten minutes. Still another type of child will find it expedient to cover an eye when he reads so that he doesn't see double. Another type of child that educators are well aware of is the one with high intelligence who is barely getting passing grades. This is the one about whom we hear the teacher complain, "He could do the work if he only tried." Often he is immature not only visually but in his total growth. In addition to developmental lenses he may need special educational guidance. Finally there is the kind of a child, usually a boy, who in the face of failure to achieve in school becomes the classroom behavior problem, a source of annoyance to the teacher, principal, and his fellow students. Except for the myopes, all of these kinds of children may have excellent visual acuity at distance—20/20 or better—but lack the ability to sustain in nearby visual tasks. Reading, and especially getting meaning out of what they have read, gives them particular difficulty. All of them can receive some measure of benefit from the proper use of developmental glasses.

What are the characteristics of developmental glasses? Such glasses are always made up of plus (convex) lenses. The effect of a plus lens on a nearby object is to displace the visual image so it is seen as though it were farther away in space. For example, though a +1.00 lens a target at 13" would be optically displaced so as to appear at 20", or a target at 16" would be displaced to 26". The same effect would not be produced by simply moving the target from 13 to 20". This is because two different visual functions are involved; the pointing, or centering function, and the focussing function. The two are ordinarily correlated, but can, to some extent, work separately. The effect of the plus lens is to allow the individual to focus his vision farther out in space than he is centering his vision. To reiterate, a +1.00 lens will allow the individual to point or center his vision at 13" while focussing at 20". This differential in distance is in the direction in which most children would prefer to operate: centering of vision inside of focus of vision. It might appear then, that one needs only to provide the child with an arbitrary amount of plus lens-power and the problem would be solved. However, the focussing and centering mechanisms of vision do not operate entirely in-



dependently of one another. Therefore, success depends upon not setting up stress in the centering mechanism of vision by using too strong plus lenses. A standard battery of visual tests at 13" or 16", used by many optometrists to determine the relationship between focussing and centering of vision, can indicate the lens power that can be worn for distances within arm's length. It is not uncommon to find a child in whom the relationship between focussing and centering of vision has become so rigid that even plus lenses of a low power set up a stress in the centering mechanism. The visual result is that the child complains of headaches or of his eyes feeling pulled after wearing his glasses. With such a child a somewhat different course of action must be followed.

A comparison of developmental lenses for children and young adults can be made with baseball: the lenses are to the children as a glove is to the baseball player. When the player is not engaged in fielding he does not wear his glove, when the child is not engaged in activities within arm's reach he does not use his glasses. It would be absurd to think of a player going to bat with his fielding glove still on his hand. Much the same kind of absurdity may exist when we expect a child to use his developmental glasses while performing such distant activities as looking at the chalkboard. Then the glasses might well produce blurred vision and become a real source of annoyance. Taking the glasses off would, of course, be one solution. But unlike the baseball player, the school child is faced with the problem of working at both positions alternately, as in copying from the chalkboard to his desk. When the power of the lenses worn for near vision blurs distance vision, then a simple solution is prescribing duo-focus lenses (bifocals). The bottom part (bifocal) contains the appropriate plus power for near distances, while the upper part, for far distances, contains little or no plus power. This permits the child to wear his glasses for all classroom activities, without the bother of having to remove them whenever he looks up from his desk.

The same procedure can be used with the beginning and progressing myope mentioned earlier in the article. Again the appropriate amount of lens power is determined for the near distance, this power is reduced to the point of allowing clear vision at distance, and the two powers are incorporated in duo-focus glasses. Formerly bifocals were used exclusively for individuals over forty years to compensate for their loss in ability to focus their eyes. Suffice it to say that the reasons for the use of bifocal lenses with children has no relationship to their use with adults.

Do developmental glasses become "habit forming" so that the child cannot get along without them and must wear the glasses all of the time? The answer is no. In re-examining children who have worn such glasses for a period of six to eight weeks we often find improved performance in visual acuity, stereopsis, and convergence stability, and lessening of suppressions. All of this occurs when the child is tested without his glasses. Complaints of inability to read for more than ten minutes without blurring, of inability to concentrate

for more than short periods of time, and of frontal headaches disappear in part or wholly. Less tension in school and easier management at home are reported where this kind of behavior has been a problem.

Developmental lenses are, of course, no panacea for the myriad of visual problems that we find among school-aged children. A glove would not be of much use to the baseball player if he did not know how to play baseball. The case is the same when the child lacks such basic visual skills as ability to focus rapidly from far away to nearby, to fixate rapidly from far to near or from side to side, to maintain fixation on a moving target, or to coordinate the vision of the right eye with that of the left in all these activities. If he cannot perform adequately in these basic areas of vision we can hardly expect him to achieve easily the complex visual skills involved in securing meaning and understanding from printed symbols.

Despite generally faulty visual skills, many children can still achieve the low level skills of form discrimination (can have "20/20 vision"). Because of their accurate performance in tasks demanding discrimination (such as reading an "eye chart") we have often in the past made the mistake of thinking that a visual problem did not exist. We now recognize that in such cases (and they are quite common within our school population) it is first necessary to train these focussing, fixating, and coordinating skills before the children will be ready to profit from developmental lenses. Vision, like all motor skills, can be improved by practice. Some children, in their natural course of development, learn more effective visual skills than do others. When children lack the essential basic skills it is possible to program a course of visual training for these youngsters in much the same manner as one would plan instruction in how to dance, how to play a musical instrument, or how to play golf. For example, it may be necessary to begin by teaching an 8- or 9-year-old the visual skills, form perceptions, and spatial relationships that should have developed at four and five years of age.

Since our concern is with developing and protecting the child's vision, it is important that visual examinations be made early in the child's life, usually beginning around four years of age. Because the demands of school have not yet begun, such an examination gives the optometrist an opportunity to appraise the child's "natural" visual development up to this point and to make suggestions about the kinds of eye-hand activities that will encourage optimal visual development. A second examination, a year later, will, when compared with the first, reveal the direction and rate of visual development, and will allow additional suggestions to be made concerning visual activities. With the child's entrance into first grade at about six years of age, consideration can be given to lenses. Seven years appears to be a crucial development period, when the child's own demands to achieve in school and to finish his work may cause him to specialize his vision for performance within arm's length and thus to become myopic. Many children unable to make this type of

*(Continued on Page 112)*

# Lithium --- The Miracle Element

• By **Walter M. Fenton**

DIRECTOR, PRODUCT RESEARCH & DEVELOPMENT, LITHIUM CORPORATION OF AMERICA, INC.

*Except for a brief mention during the discussion of the alkali metals, lithium is practically overlooked in chemistry texts.*

*This article discusses the Post World War II developments in the chemistry and uses of lithium.*

Lithium—an element which is only beginning to come into its own has frequently been called, “the miracle element.”

Lithium is far from being a newly discovered element—as a matter of fact it was first identified in 1807 by Arfvedson in the course of analyzing a native Swedish ore—petalite. It is significant that his discovery came about because of the peculiar behaviour of a sulfate amounting to 4% of the ore which did *not* show reactions typical for sodium or potassium. Eighteen years later, Berzelius detected the presence of lithium salts in mineral waters at Karlsbad, and in 1854 Bunsen and Mathiesen succeeded in obtaining the metal by electrolysis. Not until 1893 do we find reference in the literature to lithium and then only in a modification of the cell bath for production of the metal. During World War I the Germans desperate in their shortage of more common metals utilized lithium in a zinc—aluminum alloy. Subsequently, the Germans developed certain other alloys; but none of them reached commercial proportions.

Prior to World War II, lithium—either in the form of the metal or its salts, had very little commercial application and was the subject of very little research investigation. Alkaline cell batteries, aluminum welding, a few special glasses, some air conditioning, and soft drinks—this was the entire picture.

Today in 1956, productive capacity in this country alone is estimated unofficially at over 45,000,000 pounds (basis lithium carbonate). Why was this potential giant permitted to slumber for over fifty years? Lithium has a valence of one by reason of its electronic configuration; hence, it was placed in Group I and there it rested undisturbed for years. For years instructors and researchers dismissed lithium as “just another alkali metal”—and an expensive one at that. The writer recalls that during his original studies in Inorganic Chemistry, lithium was passed over as inconsequential. But consider, if you will, the factors that led to the discovery of this element—its unique behaviour as contrasted to the other Group I elements—principally sodium and potassium.

Yet, presumably, these dissimilarities escaped the attention of researchers for years. It has been only in recent years that researchers have begun to recognize that lithium, rather than just being another alkali metal

is in reality, a unique element with properties that more closely resemble the Group II and Group III elements. Certain of the inorganic lithium compounds are insoluble whereas the corresponding sodium or potassium salts are quite soluble. It forms soaps which are insoluble—a property common to barium and aluminum. In combination with alkyl and aryl groups it finds use as a Grignard reagent—a property heretofore considered a unique property of Magnesium. The halides of lithium are extremely hygroscopic—thus resembling the halides of calcium and magnesium. Thus it can be seen that once these unique properties are recognized and put to work, lithium becomes a very useful tool.

Let us look now at the uses to which lithium has been put as a result of these unique properties. For the purpose of this article, it would perhaps be better to consider these uses from the standpoint of uniqueness; rather than commercial value.

In the field of organic chemistry, the use of lithium has been limited to the production of lithium soaps for greases and Grignard-type reactions for various intermediates of value in the pharmaceutical field. Quite recently, F. W. Stavely and his co-workers at Firestone Tire and Rubber Company, have determined that lithium is an excellent ionic catalyst in polymerizing isoprene. This is the new “Coral Rubber” recently announced by Firestone. Stavely reports that lithium appears to be unique as a catalyst in the production of isoprene in that it strongly favors the formation of *cis* 1,4 structure to the exclusion of *trans* 1,4 and 1,2 structural arrangements. The other alkali metals give entirely different structures. The interesting point here is that the Hevea polymer—the one in natural rubber is predominantly of a *cis* 1,4 structure. Thus, by employing the unique properties of lithium an entirely new field of polymer chemistry may have been opened up.

In an entirely different field, properties of lithium metal not heretofore known, have been discovered. In the brazing of stainless and other high alloy steels a filler alloy is used to braze the faces together. Conventionally, a flux must be used to wet the metal and clean the surface of interfering oxides. N. Bredz has developed a series of lithium-bearing alloys which are self-fluxing thus eliminating the need of using a chemical flux (normally a messy procedure). The lithium reduces the melting point of the brazing alloy, combines with the oxide coating on the base metal, thus performing the function of the chemical flux. In some cases it is possible to dispense with protective atmospheres which are widely used in these operations. This obvious improvement in an important industrial operation has occasioned a lively interest in further applications.

During World War II, the armed forces were seeking a universal lubricating grease which could be used for a multitude of uses for planes, tanks, trucks and all manner of materiel under a variety of conditions. Prior to this time there was a collection of greases based on sodium, calcium, barium and graphite. Sodium greases have high melting points but they dissolve easily so they are unsuitable under wet conditions. Calcium greases are water resistant, but they melt easily and hence cannot be used where high heat of friction is developed. When the first lithium-base greases were developed many of the armed forces' operational maintenance problems were solved. Lithium greases have high melting points and low freezing points and hence are useable over a wide range of temperatures. They are water insoluble and this property widens their field of applications. They can be used winter or summer, whether the day be wet or dry—in short, lithium greases are truly all-purpose.

In the field of ceramics, the unique properties of this miracle element have been put to practical use in enamelling steel and cast iron at lower temperatures than obtained heretofore. There are many ways of lowering the melting or softening point of a porcelain enamel but these methods generally result in an inferior and less durable finish. By introducing a lithium salt in economical percentages, the firing temperature of the enamel can be reduced by 100 to 200 degrees, yet the resultant "hard" enamel meets the most exacting requirements. In the case of cast iron bathtubs, a so-called "stainless" enamel can be applied in one-third the time that non-lithium, high-silica enamels can be applied.

One of the most rapidly growing uses for lithium is in the field of air-conditioning. By way of clarification it might be well here to identify the type of air-conditioning where lithium is employed. The conventional type which operates on the cooling effect of an expanding gas does not lend itself to the use of lithium. Rather, the gas absorption type and the brine spray type are both based on the use of lithium halide brines. In the gas absorption type, a 54% solution of lithium bromide is heated until part of the water of solution is driven off. This results in a significant loss of heat, so that the water of solution acts as the coolant—making for a very simple unit—with very few moving parts and hence low maintenance costs. In the Kathabar type, a 40% solution of lithium chloride is sprayed on the warm, moist incoming air and the moisture removed, thus effecting a lowering of humidity and heat.

Returning again to organic chemistry, we find another unique property of lithium being put to good use. Lithium metal shares with magnesium the peculiar property of attracting to itself certain organic groups—alkyls and aryls. In subsequent reactions, the lithium delivers these groups where needed, attaching them at the desired points of a benzene ring or straight chain molecule. This unique reaction is employed during one of the steps in the production of synthetic Vitamin A. Specifically, beta-ionylenecrotonic acid is reacted with methyl lithium to produce the desired C19 Ketone. Re-

cently several new pharmaceutical products which have come on the market have been made through use of this type of reaction.

Other commercial uses for lithium are found in industry, such as the use of lithium chloride and lithium fluoride in fluxes for the brazing of aluminum; lithium amide in the preparation of antihistamines; lithium carbonate and various special lithium ceramic compounds in the preparation of ceramic color oxides; lithium hydride in the preparation of lithium aluminum hydride and other double hydrides for organic reductions; lithium-copper cartridges for degasification of copper, brass and bronze castings.

So much for the past and present—but what of the future? Let us keep in mind that 90% of the uses to which lithium is being put today were unknown ten years ago. Each present use is based on some unique property of this curious element. What are the possibilities of applying these same unique properties to uses as yet unheard of? The answer to this question lies in the research laboratories of this country—in industrial organizations, in colleges and universities and in research institutes. To say that the work done over the past ten years has only scratched the surface is to put it mildly. Researchers are constantly discovering new properties of this strange element.

What is in the foreseeable future for lithium? New uses already under commercial evaluation have already been mentioned here; in rubber and in brazing alloys. There are many more possibilities under investigation at the present time. One of the most significant is in the field of atomic power. The tremendous heat developed in the atomic core from the fission of uranium or thorium must be carried off quickly and efficiently for transfer to the boilers of the power plant. While there are a number of heat transfer agents used, even water—nevertheless liquid metals display such efficiency that they are being evaluated widely by the atomic energy commission engineers and others interested in the subject. Those metals which show the best possibilities are sodium, sodium-potassium, lead, mercury, bismuth, lead-bismuth and lithium. Now, to be of value as a heat transfer agent, a metal should have a low melting point, a high boiling point, a low density and high heat capacity. Of the above-mentioned metals, lithium is superior in every qualification. However, tests to date have shown it to be highly corrosive to most metals of construction, although it is not clear at this point as to whether this corrosion is due to the metal itself or to impurities picked up in its manufacture and handling. If the latter is true, then the improvement in quality of the lithium metal could open up a vast new field of application, not only in atomic power but in conventional industrial operations. In the field of organic chemistry, a vast amount of research is under way which may lead to use of organolithium techniques and organic reductions with lithium metal, particularly in the manufacture of pharmaceuticals.

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# Industry Sponsored Teaching Aids Come of Age

• By G. P. O'Connell

ASSISTANT DIRECTOR, EDUCATIONAL RELATIONS SECTION, PUBLIC RELATIONS STAFF, GENERAL MOTORS CORPORATION, DETROIT, MICH.

*Students often fail to realize that the laws and theories studied in class have many important applications in the world of industry.*

*Industrial organizations provide many teaching aids to educators. These aids not only point out the practical aspects of text-book principles but also explain technical facts in an interesting and non-technical manner.*

Today, it is a rare individual, indeed, who does not recognize the impact that the application of scientific study has had on the lives of men and nations. Technological developments, whether for benign and peaceful purposes or for defense, have become familiar objects of conversation even to the non-technical man or woman. Television, for example, goes much farther in its extension of the communicative arts than did its forerunner, radio; primarily because its visual presentation affords a much closer identification between the viewer and the viewed.

The uses of atomic energy for war and peace are much farther reaching in their effects upon the life of the average citizen of the world than were the effects of those older stalwarts of military and industrial power—dynamite, coal, steam, electricity and gasoline. The scientific principles which form the basis for these modern applications are not new, but the applications themselves have taken on an awesome, dramatic and even commanding quality that no thinking person can ignore.

How men apply science in the future will depend largely upon the judgment of those leaders who guide the political and military courses of nations. But what is evident now is the fact that science will play an even greater part—a constantly increasing part—in the destinies of men and nations. We cannot turn our backs on scientific knowledge; nor can we hold back the tide of technological advancements which are based upon the applications of scientific knowledge. Today's research projects will be the common conversation pieces of tomorrow's gatherings, while new and more marvelous ideas supplant them in the laboratories of industry and the lecture halls of our universities.

We are committed to an era of progress, and we have but one choice of direction—forward. This progression is not limited to the field of scientific investigation, of course; but the importance of this area is such that, to a large measure, it will shape the nature of progress in all fields of human activity.

Perhaps the most important element of this era of scientific progress is the intellectual calibre and quest-

ing attitude of the people who shape its course. Science and technology present continually expanding opportunities for thousands of qualified men and women in all areas of technical work. Research and engineering developments are constantly creating new and interesting jobs for those prepared to meet the challenges of the Age of Science. Each year more and more of our young people are finding satisfying and rewarding careers in physics, chemistry, the natural sciences, mathematics and engineering.

Industry is aware of the importance of scientific progress and the part it plays in maintaining and continuing our country's technical, economic and social leadership. For it is upon the application of these very principles that American industry has been built. That industry should want to extend scientific progress as well as maintain our present leadership in this field is fundamental to its very existence.

Industrial leaders, consequently, are becoming more and more cognizant of the vital role education plays in scientific progress. They are aware of the tremendous responsibility that is placed in the hands of American educators—a responsibility that encompasses the development of our future citizens, as well as the selection and training of our future leaders. Because of this, industry is increasing its efforts to arrive at a better understanding of the problems which face education. It is becoming more and more interested in how industry can help in arriving at a solution to these problems.

One broad avenue of activity that is directed toward mutual understanding is a willingness on the part of industrial corporations to furnish educators with special technical information, data, training materials and equipment for supplementing classroom and laboratory teaching. These materials provide teachers with fresh, up-to-date and realistic matter for illustrating scientific principles.

It is interesting to note the growth and development of the National Science Teachers Committee on Business-Industry Relations since its formation in 1947. The Committee was originally named *The National Advisory Council on Industry-Science Teaching Relations*, and one of its major functions was to study the problems of business and industrial sponsored teaching aids. Today the Committee addresses itself to the broader aspects of all matters of mutual concern to science teachers and industry.

Each year industrial organizations receive thousands of inquiries from teachers and students for materials to supplement their course work. These include requests for information, inquiries concerning the availability of published booklets, technical manuals, company reports, and the procedure for obtaining such visual aids



as charts, displays, company products and equipment. That industry is enthusiastic in its response to these requests, and that teachers find these materials valuable in their work, is attested by the many thousands of new and repeat requests educators direct to business and industrial organizations yearly.

A significant outgrowth of industry-education co-operation has been the establishment of special sections or departments within many companies for—1) handling educational requests and 2) developing ways and means for furthering better relations with our schools. Not only do these departments expedite the distribution of teaching aids; but, at the suggestion of educators, they develop or sponsor additional materials. It is often difficult for a teacher seeking information or materials from a large, national organization to determine the most expedient course of approach. As a result, very often his request is mis-directed or delayed to an extent where the material is no longer useful in his teaching (at least for his present class of students). By centering its educational services under a staff function, Public Relations, for example, such occurrences can be kept at a minimum. The department or section then functions as a central clearing point for coordinating the development, processing and distribution of technical aids to schools. In this way industry has been able to render a more effective educational service.

The work of the General Motors Educational Relations Section is typical of one industry's efforts to help teachers and students—to the extent that industry can help—in carrying on the important job of education. Its Director has had extensive experience in both the industrial and educational fields, and his staff is composed, for the most part, of persons whose work has always been closely associated with education—at both the secondary and college levels.

Because the automotive industry in general, and General Motors in particular, has been founded and built upon scientific and technical progress, it is natural that a major share of the requests it receives from teachers and students should be in these general areas of knowledge. At the college level, GM makes available to engineering faculty members and school libraries the *General Motors Engineering Journal*, a publication which serves as a medium for presenting to the field of engineering education results of General Motors research and engineering developments—both in the product and production fields.

Reprints of articles and speeches by GM engineers and scientists which have appeared in technical publications or have been presented to learned groups are also available to educators and school libraries on request. Technical addresses to student and faculty groups by GM executives are arranged whenever possible. Many GM divisions have produced specialized films and filmstrips on technical subjects. These include "Shell Molding," a film produced by the Fabricast Division and distributed on a loan basis to foundry and metallurgical groups, and "The Chemical Stability of Sealed Re-

frigerants," produced by Frigidaire Division and used largely in chemistry and refrigeration courses.

In line with requests received from educators at the secondary school level, GM produces and makes available to schools a number of booklets. These publications treat technical subjects and how scientific laws and principles are applied in automotive, aircraft, Diesel engine and refrigeration development. They are written in simple, non-technical language, and have an objective approach with an absence of product advertising. Because of this they have had widespread use by both teachers and students in chemistry, physics, mathematics and industrial courses. The following titles and descriptions are suggestive of the educational scope of these booklets: *A Power Primer*, *Power Goes To Work*, *Electricity and Wheels*, *Precision—A Measure of Progress*, *Optics and Wheels*, *Metallurgy and Wheels*, *A to Zero of Refrigeration* and *Short Stories of Science and Invention*.

Motion pictures, many of them in full color, have been developed around the subjects of these publications. At the present time there are more than fifty titles listed in the General Motors Film Catalog, and new ones are added from time to time. These films have had widespread use by audio-visual and classroom teachers, not only for their illustrative value, but because they very often provide an inspirational motivation for students to pursue technical and scientific careers. Popular among teachers of science and mathematics are such films as *The Questing Mind*, *The ABC of Jet Propulsion*, and *Diesel, the Modern Power*.

General Motors also produces and directs the *Previews of Progress*, a dramatic, educational, stage presentation written specifically as a high school assembly program and presented as a live show without charge. The theme of the presentation is that there are unlimited opportunities awaiting American youth in all branches of scientific and technical endeavor. By using original experiments in the fascinating field of popular science to help develop this theme, *Previews of Progress* not only entertains, but also helps to inspire a zeal for science in many students.

The Educational Relations Section has answered educators' requests for inspirational and informational materials to encourage students to pursue technical careers in engineering and the skilled trades through its publication of "Can I Be An Engineer?," "Can I Be A Craftsman?" and other guidance booklets. Through personal contacts, exhibits and financial assistance, General Motors participates in numerous career activities, cooperative business-industry-education programs, Future Scientists of America Foundation projects and other worthwhile educational activities.

If we as a nation are to grow and progress in world leadership, it is imperative that the number of our scientific leaders be increased proportionately. Industry management, perhaps more than any other group, appreciates America's dependence on scientific leadership and the role it will play in our future.

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# Fractionation of Carboxymethylcellulose

• By **E. J. Quinn, M.S.**, (University of Illinois) and  
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BLOCKSON CHEMICAL COMPANY, JOLIET, ILLINOIS

*Carboxymethylcellulose, a synthetic derivative of nature's cellulose, has in addition to all the properties of the original cellulose, the property of water solubility.*

*Here is a study of a fractionation of this interesting cellulose derivative.*

In a recent study, Timell<sup>1</sup> fractionated various laboratory preparations and commercial samples of sodium carboxymethylcellulose in order to determine the chemical uniformity of this substance. He came to the conclusion that the fractions varied more in degree of substitution than in molecular weight and that the samples investigated could be resolved into three parts:

1. A minor portion exhibiting a high D. S. (degree of substitution) and low D. P. (degree of polymerization).
2. A large fraction of considerable chemical uniformity.
3. A third non-uniform portion with a low D. S.

Prior studies<sup>2,3</sup> had likewise indicated a non-uniformity of sodium carboxymethylcellulose particularly in connection with rheological behavior. In earlier studies from this laboratory<sup>4</sup>, a method based on whiteness retention was found useful in assaying various carboxymethylcellulose preparations<sup>5</sup> for laundrometric activity, and it seemed desirable to extend this technique to fractionated sodium CMC samples. With this in mind, four different commercial samples of CMC were purified by precipitation, conversion to the free acid and reconversion to the sodium carboxymethylcellulose. The purified sodium salt was then extracted with varying concentrations of aqueous methanol and the fractions so obtained were assayed by the whiteness retention method. The sources and designations of the various samples used for the preparation of the purified sodium salts are listed in Table I but are not individually identified throughout the manuscript.

Table I. Commercial CMC Samples Used in Study

Source	Designation
Antara	Colloresine LV
Du Pont	Sodium CMC 10 D
Hercules	CMC CT Grade Medium
Wyandotte	Carbose D

## Purification of Commercial Samples

Ten grams of each commercial sodium CMC sample simply designated by the alphabetical letters from A through D were dissolved in 200 ml. of distilled water with vigorous stirring and the solution was added slowly with stirring to 800 ml. of 95% ethanol. The white precipitates were collected in each case by suction filtration, washed successively with 100 ml. portions of 80% ethanol, 95% ethanol and ether. After drying for one hour in a vacuum oven at 60° C., each sample was weighed and the percent recovery is listed in Table II.

For conversion to the free acid, 7 grams of precipitated sodium CMC was dissolved in 200 ml. of distilled water with stirring. Concentrated hydrochloric acid was added dropwise to a pH of 2 and after stirring for 5 minutes the opaque liquid was added slowly with agitation to 800 ml. of 95% ethanol. Agitation was continued for 15 minutes and the precipitate and solution were allowed to stand for 24 hours before filtration. The precipitated free acids were collected and washed with 80% ethanol. However, since all of the samples gave slight tests for chloride ion, additional washings were carried out with 80% methanol, anhydrous methanol and ether until a negative test for chloride was obtained for each. Table II shows percent recovery of free acid from each of the samples of precipitated sodium carboxymethylcellulose adjusted for molecular weight change.

In order to prepare pure sodium carboxymethylcellulose, 5 grams of the free acid was suspended in 100 ml. of distilled water along with a theoretical quantity of 1 N sodium hydroxide solution and the mixture was mechanically shaken for ten hours at which time complete solution was effected in all four cases. To each solution anhydrous methanol was added with stirring

Table II. Purification of Commercial CMC Products

Sample	Commercial Product (I)		Reprecipitated Sodium CMC (II)				CMC Free Acid (III)		Purified Sodium CMC (IV)			
	% Na	W.R. <sup>a</sup>	% Recovery from I	% Na	D.S. <sup>b</sup>	W.R. <sup>a</sup>	% Recovery from II	% Na	% Recovery from III	% Na	D.S. <sup>b</sup>	W.R. <sup>a</sup>
A	8.35	56.4	92	7.55	0.77	58.7	96	0.75	96	6.78	0.66	59.0
B	15.7	48.5	81	6.65	0.64	51.1	97	0.80	98	6.23	0.59	52.9
C	9.50	53.0	92	6.95	0.69	57.2	97	0.86	98	6.01	0.56	59.5
D	16.3	45.5	82	5.65	0.52	53.0	96	0.35	98	5.30	0.48	54.7

<sup>a</sup> W. R. = whiteness retention as % reflectancy

<sup>b</sup> D. S. = apparent degree of substitution calculated from % Na

to give an 80% alcoholic solution and after the precipitated sodium CMC had settled it was collected by filtration and washed with methanol and ether as described above. The yields of purified sodium carboxymethylcellulose prepared from purified free acid are listed in Table II. Table II also records the whiteness retention assays expressed as % reflectancy and sodium analyses at each stage of the fractionation. The sodium analyses were carried out using a Perkin-Elmer flame photometer Model 52 A. The degree of substitution in each case was calculated from the sodium analysis. The purified sodium CMC samples were used in the fractionation steps described below.

#### Fractionation of Purified Sodium Carboxymethylcellulose

The fractionation of each of the purified sodium CMC samples (IV in Table II) was carried out in the following manner. Using an automatic shaking machine 4.5 grams of each sample was placed in a 250-ml. glass-stoppered Erlenmeyer flask with 100 ml. of 65% methanol and shaken for five hours. The insoluble portion of the CMC was removed for filtration and the soluble material was isolated by addition of methanol to a concentration of 80% with subsequent washing of the precipitate with methanol, ether and drying. The insoluble fraction was next shaken with 60% methanol and again the soluble fraction was isolated by precipitation with added methanol. This procedure was repeated through methanol concentrations of 57.5% and 55% respectively and the final residue consisted of material insoluble in the latter concentration. The weights of each fraction as well as sodium analyses, degree of substitution and whiteness retention assays

Table III. Fractionation of Purified Sodium Carboxymethylcellulose Samples

Fraction		Sample (4.5 g)			
Soluble in		A-IV	B-IV	C-IV	D-IV
65% Methanol	wt. in g.	0.9485	0.8196	0.8868	0.7810
	% Na	—	3.93	5.77	2.34
	D. S. <sup>a</sup>	—	0.30	0.53	0.18
	W. R. <sup>b</sup>	61.5	56.4	60.5	56.5
60% Methanol	wt. in g.	1.8106	1.8946	1.8217	0.8584
	% Na	5.55	5.19	6.35	4.53
	D. S. <sup>a</sup>	0.50	0.46	0.60	0.39
	W. R. <sup>b</sup>	61.8	54.4	62.1	57.8
57.5% Methanol	wt. in g.	0.9834	0.9915	1.4144	1.6777
	% Na	—	5.55	5.62	4.82
	D. S. <sup>a</sup>	—	0.50	0.52	0.42
	W. R. <sup>b</sup>	62.5	63.8	54.7	56.2
55% Methanol	wt. in g.	0.3479	0.4679	0.0879	0.6013
	% Na	—	6.02	5.63	4.85
	D. S. <sup>a</sup>	—	0.56	0.52	0.42
	W. R. <sup>b</sup>	58.8	53.3	55.7	53.0
Residue	wt. in g.	0.0936	0.0681	0.0971	0.3973
	% Na	7.08	—	—	4.93
	D. S. <sup>a</sup>	0.70	—	—	0.43
	W. R. <sup>b</sup>	59.2	54.5	39.2	52.5
Total weight recovered, grams		4.1840	4.2417	4.3079	4.3157

<sup>a</sup> Apparent degree of substitution, i.e. number of carboxymethyl groups for each anhydroglucose unit.

<sup>b</sup> Whiteness retention expressed as percent reflectancy.

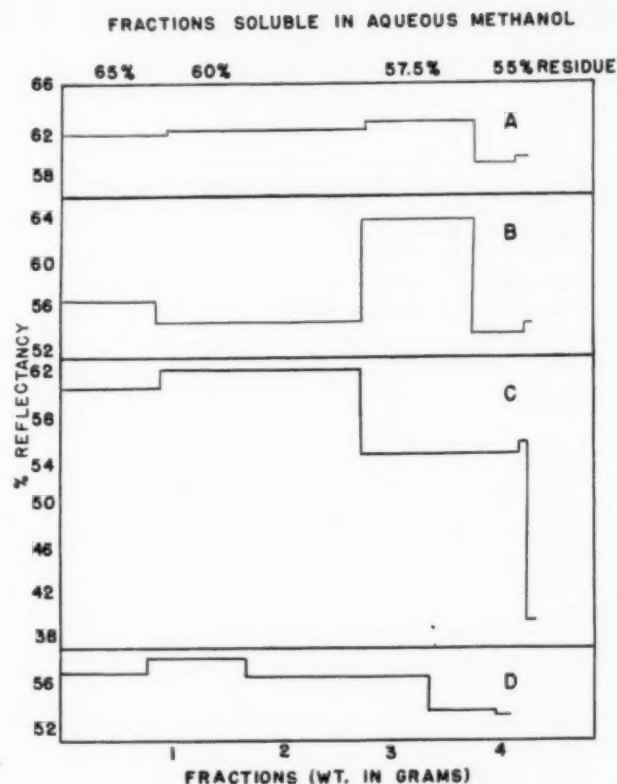


FIGURE 1. Variation in the whiteness retention values of fractions extracted from purified sodium CMC in succeeding order by 65%, 60%, 57.5%, and 55% aqueous methanol.

are indicated in Table III. In addition the whiteness retention assays of each fraction isolated in decreasing methanolic concentration are shown in Fig. 1.

#### Discussion of Results

The results in Table II indicate that two of the commercial CMC samples contain significantly larger amounts of sodium chloride than do the remaining two products. Although most of the salt is removed by precipitation from 80% ethanol, a small part is carried along with the sodium CMC. However, the traces of sodium chloride may be removed by precipitation of the free carboxymethylcellulose and subsequently washing the product with 80% methanol. Even after the CMC is chloride-free it contains a definite amount of sodium, perhaps indicating that some of the sodium is bound to the cellulose portion of the molecule rather than to the carboxyl group. If this were true, then the degree of substitution, i.e. the number of carboxymethyl groups per anhydroglucose unit, would actually be lower than that calculated from the sodium analyses.

It should also be noted that the purified sodium CMC samples used in the fractionation studies contain less sodium and hence show a lower D.S. than the once-precipitated material.

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# The Chemistry and Uses of Lignin

• By **Blanche B. White, M.S.**, (University of Chicago)

SUMMIT RESEARCH LABORATORIES, CELANESE CORP. OF AMERICA

*The production of the paper for one of New York's newspapers uses nearly two thousand acres of forest annually. Lignin is an abundant by-product of the paper industry.*

*Despite its abundance and its many potential uses no large scale use of lignin has been developed.*

*The author outlines the present chemical and economic status of lignin.*

In an economy which prides itself on its efficiency in the utilization of industrial by-products, lignin remains a challenge to the chemical world. A rapidly expanding wood pulp industry annually produces 12,000,000 tons of chemical pulp and incidentally finds itself with about half this quantity of lignin, in one form or another, of which it must dispose. Lignin, aside from cellulose and hemicelluloses is the main constituent of all extracted woods and constitutes about 25% of the total weight, along with roughly 50% cellulose and 25% pentosans and other hemicelluloses. The potential production of lignin in Canada and the United States from pulping waste alone is approximately 8,000,000 tons a year. In addition, lignin has been isolated from plants other than wood such as ferns, grape epicarp and grape seed, cork, cottonseed hulls, etc.

This material was first recognized in 1838 by Anselme Payen, who proved that wood was not a chemical entity as it had been previously considered. He was able, by alternate treatments with nitric acid, caustic soda, ethyl alcohol and ethyl ether, to isolate a fibrous material, cellulose, and a residue with higher carbon content which he called "la matière ligneuse véritable" or "the true woody material." Later, in 1857, F. Schulze found that a mixture of nitric acid and potassium chlorate removed "the incrusting substances" in wood, which he designated as "lignin," a term derived from the Latin word, "lignum" or wood. It has since been established that, because his reagent dissolved not only lignin but large amounts of carbohydrates consisting mostly of wood polyoses, his estimate of the amount of lignin in wood (50%) was high and his formula,  $C_{19}H_{24}O_{10}$ , based on elementary analyses, was low in carbon.

Because the structure of lignin is still unknown, its definition is difficult. The term lignin is a collective term for a group or system of high molecular, amorphous compounds, chemically very closely related. It may be defined as that part of the incrusting material of the plant which is built up mainly, if not entirely, of phenyl propane building stones. It carries a major part of the methoxyl content of the plant, is unhy-

drolysed by mineral acids and is easily oxidized. It is soluble in hot alkali and bisulfite and condenses readily with phenols and thio-compounds. It gives a series of color reactions with phenols and amines which are not specific for lignin but are not given by other plant components; these, therefore, serve as a means of identification.

Whether or not the lignin in wood is attached to the carbohydrates is still an unresolved question. Most of the reactions of lignin *in situ* indicate that it is not free to react in the same manner as isolated lignin. It may, therefore, be attached to the carbohydrates, cellulose and hemicelluloses, which also react much more easily when free of lignin. However, an X-ray study of wood shows the regular cellulose pattern and, therefore, indicates to some investigators that lignin and cellulose are not chemically combined. Similarly, shadow-graph pictures of a delignified section of wood obtained with the electron microscope show a uniform cellulose surface which seems to preclude the possibility of a combination with lignin.

The principal difficulty in lignin chemistry and in determining the structure of lignin is the fact that no method can be found to isolate total lignin in its original state. Brauns has isolated a fraction representing 1-2.5% of the wood (8-10% of the lignin) by extraction of wood with ethanol at room temperature for a long period of time<sup>1</sup>. Before isolation of lignin, the wood is extracted to remove resinous and other substances. The lignin thus isolated has been designated as "native lignin" in contrast to "acid lignins," so called because they are obtained by action of strong mineral acids on the lignified material. Lignin may also be isolated by methods which put it into solution, as in the sulfite solution method used in commercial sulfite pulping and the alkali solution method used in the commercial soda process and the sulfate or Kraft process.

It has been established that lignin contains only carbon, hydrogen and oxygen. The average elementary composition which varies for different types of wood is approximately C = 63%, H = 6%, O = 31%<sup>2</sup>. Lignin has a density of 1.37<sup>3</sup> and a refractive index of 1.61<sup>4</sup>. The maximum ultra-violet light absorption spectra of several lignin preparations were found to be about 2,800 "Angstrom units"<sup>5</sup> ( $2.8 \times 10^{-5}$  cm). X-ray patterns of several lignin preparations were of a non-crystalline nature<sup>6</sup>. Molecular weight measurements on solutions of lignin indicate that it is a mixture of molecules of varying molecular weight, ranging from approximately 1,000 to 100,000<sup>7</sup>.

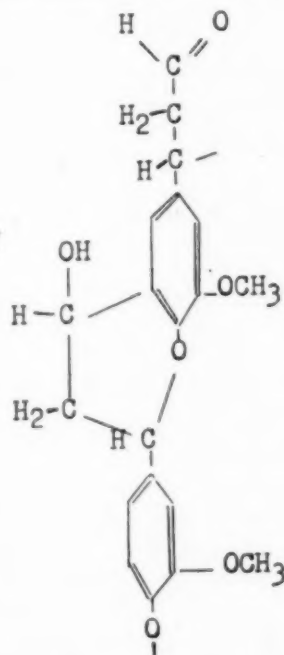
In spite of the tremendous amount of research which has been carried out during the past five decades, a definite constitutional formula cannot yet be assigned to lignin. Certain constituent groups have been identi-



fied and a number of structural formulas have been suggested.

The methoxyl group is one of those used as an identifying group for lignin and to establish its purity. This group is present to the extent of 15-20%. It has also been established that all or most of the methoxyl groups are attached to aromatic nuclei<sup>8</sup>. The presence of hydroxyl groups in lignin is indicated by the fact that it can be acetylated and alkylated. The hydroxyl content amounts to about 10% and it is claimed that the ratio of phenolic to aliphatic hydroxyl is 1:4 in a lignin of molecular weight of 840<sup>9</sup>. Since lignin reacts with phenyl hydrazine, it is concluded that the carbonyl group is also present<sup>10</sup>.

The appearance of aromatic compounds in distillation, alkali fusion, hydrogenation and oxidation products proves quite conclusively the aromatic structure of the lignin nucleus<sup>11</sup>, and this is further confirmed by ultra-violet absorption spectra<sup>12</sup>. The isolation of 45% propyl cyclohexane from hydrogenation products of lignin<sup>13</sup> and of high yields of vanillin by oxidation of lignin<sup>14</sup> is further proof of the fact that lignin is made up of multiples of propyl methoxy phenolic units. Typical of the structures proposed to explain the known behavior of lignin is that of Freudenberg<sup>14</sup> in which propyl 2-methoxy phenyl groups are united by the loss of water to form compounds with oxygen rings such as:



Lignin, as a waste product from pulping operation occurs in its soluble forms, in the effluent of pulp mills. The soda process which produces about 5% of the total chemical pulp, depends on the solvent power of sodium hydroxide for lignin and its hydrolytic effect on hemicelluloses. The spent pulping liquor or black liquor contains pulping chemicals as well as lignin, hemicelluloses and salts. Lignin can be precipitated from it by passing carbon dioxide through the liquor. The residual

liquors are then concentrated and burned to recover sodium hydroxide as soda ash. Lignin recovered from the soda process is more suitable for use in hydrolyzed wood plastics than lignin recovered from the spent liquor of other pulp processes<sup>16</sup>. This is a limited market for lignin and gives a product which must show a cost advantage to be competitive with phenol-formaldehyde resins employing wood flour filters.

The sulfate pulp process uses sodium sulfide and sodium hydroxide to dissolve out the lignin in wood. This mixture has a strong dissolving action and attacks cellulose less than does sodium hydroxide alone. It is absolutely necessary for economic reasons to recover the alkali in the cooking or "black liquor." This is done by combustion and melting. The salts thus freed from organic matter are causticized with lime. The chief interest in this process is to carry out the alkali regeneration in a manner as economical in the use of heat as possible. There have been attempts to obtain valuable chemicals formed during this regeneration such as methyl alcohol, acetone, methyl ethyl ketone, but these processes are not in actual use.

Sulfite waste liquors, then, are the chief source of lignin. Until very recently calcium bisulfite has been used almost exclusively in this process. It is believed that the sulfite group becomes attached to lignin forming an insoluble compound which is hydrolyzed at higher temperatures to lignin sulfonic acid, which is soluble and a stronger acid than the cooking liquor; a salt is then formed. Until recent years most of the sulfite liquor was run into sewers and streams. Because these liquors have a high biological oxygen demand, they may cause stream pollution. A great deal of research has been conducted, therefore, to eliminate both pollution and waste. Evaporation merely for the recovery of pulping chemicals and burning of organic matter for the recovery of heat, as in the soda and sulfate processes, has not been profitable in the United States because lime is a much cheaper chemical than soda. When other bases such as soda, ammonia or magnesium are used evaporation and burning are employed.

The literature abounds with descriptions of attempts to utilize calcium sulfite waste liquors. Some of the most significant applications will be discussed here.

One of the best known uses of lignin from waste liquor is in the preparation of vanillin, which is obtained on heating with sodium hydroxide. However, the amount of vanillin which can be consumed is a small percentage (about 0.1%) of the possible production. Rather good yields of vanillic acid in addition to vanillin, acetoguaiacone and other substances have been obtained by treating ligninsulfonates in alkaline solution with mercuric or silver oxide<sup>17</sup>. Vanillic acid esters have proved themselves useful as food preservatives and disinfectants. 5-Hydroxy-mercuri-vanillin is a good slime control agent<sup>18</sup>. Amines, ureas and similar derivatives have also been prepared from vanillin.

Lignin has been used in the lead plates of storage batteries<sup>19</sup> for a number of years because of its re-

(Continued on Page 109)

# A Student Project in Polarography

• By Margaret W. Greene, M.S., and Ann Boor Elion

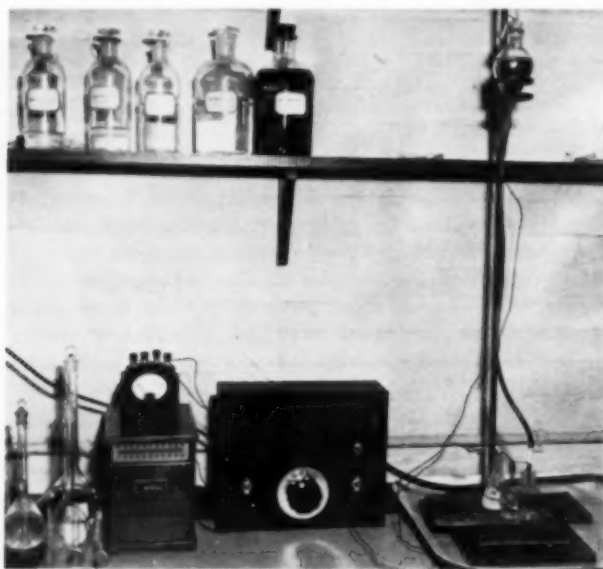
ELMIRA COLLEGE, ELMIRA N. Y.

*This is the second article describing a project completed by a student of Miss Greene. The first project, "A Student Fluorescence Meter," was published in our June 1955 issue.*

*Miss Boor not only completed an excellent research project but by her efforts the laboratory now has the use of a versatile analytical instrument.*

The construction of a usable instrument for advanced analytical work makes a satisfying and educational project for the superior student. The student undertakes a research project with all its challenges—the literature search, the design and construction of the apparatus, the use of the apparatus, and finally, the writing of a paper describing the process. The fact that the instrument becomes a part of the permanent equipment of the laboratory lends an additional feeling of accomplishment. The project described is the second of its kind undertaken in the chemistry department at Elmira College. (See *The Science Counselor*, vol. XVIII, p. 59, June 1955.)

The originator of polarographic analysis, Otto H. Müller, defines it "as a method of analysis based on the electrolysis of a minute fraction of a solution in a cell consisting of one small easily polarizable electrode and one large non-polarizable electrode." (*J. Chem. Ed.* 18, p. 65, 1941.) The method may be used for qualitative or quantitative analysis of both inorganic



A CANDID VIEW of the equipment and space utilized.

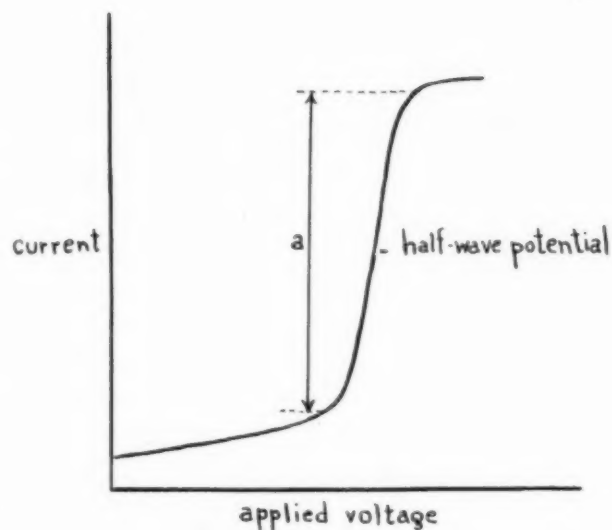


FIGURE 1

and organic materials, and ranks with emission spectroscopic and colorimetric technics in practical utility. The process differs from the usual electrolytic methods because the bulk of the solution remains unchanged.

A very small easily polarizable electrode, immersed in the test solution, is connected to a large reference electrode. A known voltage is applied, and as the voltage is gradually increased the current corresponding to each voltage is measured by a galvanometer. When the applied voltage has reached a value at which some material in the solution will react, the current increases rapidly and continues to do so as the voltage is increased until all the reacting material which reaches the electrode in unit time is electrolyzed. This results in a curve resembling that shown in Figure 1.

Each reacting substance has a certain half-wave potential which can be determined from the potential at the point of inflection of the curve. This serves as the basis of qualitative polarography.

The distance "a" (Fig. 1) is the wave height and is a function of the concentration of the reacting substance and is the basis of quantitative polarography.

Two or more ions whose half-wave potentials are sufficiently different may be determined simultaneously by their individual, characteristic waves. The concentration of ions studied polarographically usually falls within the range  $10^{-2}$  to  $10^{-5}$  Molar.

The most widely used electrode employs dropping mercury. It has several advantages over other electrodes. Among these are: reproducible smooth fresh surface,

low decomposition potential. A reference electrode must also be employed, the saturated KCl-calomel cell being most suitable.

### Construction

A satisfactory instrument can be constructed from apparatus which is common in most laboratories. In addition to the electrolysis cell, three units are required: a source of E. M. F., a polarizing unit, a galvanometer. A very simple apparatus is illustrated in *Scientific Apparatus and Methods* published by E. H. Sargent and Co., Summer 1948. We felt that a self-contained unit which would not require reassembly each time it was to be used would more nearly satisfy our requirements.

The wiring diagram of our instrument, Figure 2, is a modification of that devised by Müller. Additional information about the quality of material required in the construction was obtained from an article in the *Journal of Chemical Education*, 25, p. 224-5, 1948.

The materials required for construction of the complete instrument are listed below.

Box to house the parts shown in Figure 2—constructed from "Presdwood"—11½ inches long by 9 inches high by 4½ inches deep. The top is removable. The front panel is screwed on and carries all wiring and small parts except the batteries. These stand behind a low wood strip across the length of the box and 3 inches from the back;

V—an inexpensive voltmeter;

B—three or four dry cells;

G—a sensitive galvanometer.

The following parts were obtained from radio supply houses for less than twelve dollars:

R<sub>1</sub>—radio potentiometer, linear taper, 100 ohms;

R<sub>2</sub>—radio potentiometer, linear taper, 20 ohms;

S<sub>1</sub>, S<sub>2</sub>—single pole, single throw toggle switches;

S<sub>3</sub>—double pole, double throw toggle switch;

S<sub>4</sub>—non-shorting, 6 position switch (Central Radio

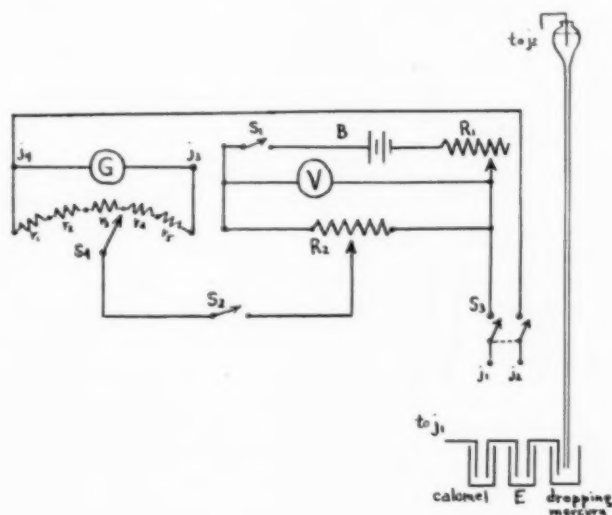


FIGURE 2

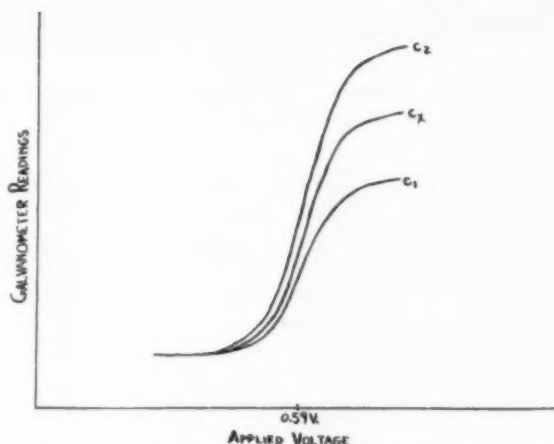


FIGURE 3. EFFECT OF CONCENTRATION OF  $\text{CdCl}_2$  ON WAVE HEIGHT

Lab., number 1401, 75 cents);

j<sub>2</sub>, j<sub>4</sub>—two red plugs and jacks;

j<sub>1</sub>, j<sub>3</sub>—two black plugs and jacks;

R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub>, R<sub>5</sub>—1% tolerance resistors. R<sub>1</sub> = 2 ohms, R<sub>2</sub> = 25 ohms, R<sub>3</sub> = 250 ohms, R<sub>4</sub> = 2500 ohms. The value of R<sub>5</sub> was selected so that the sum R<sub>4</sub> + R<sub>5</sub> would approximately equal the critical damping resistance of the galvanometer. In our case R<sub>5</sub> = 7500 ohms;

Miscellaneous—hook-up wire; two bar knobs, a 3-inch plate (and knob) for R<sub>2</sub>. The plate should have about 20 divisions to the inch. Such an assembly can be purchased for about 70 cents from the Radio Shack Corporation of Boston.

The arrangement of parts can be seen clearly in the photograph. The six position switch, S<sub>4</sub>, is nearest the galvanometer.

We felt that we should obtain the exact voltage for every position of R<sub>2</sub> at ten equally spaced settings for R<sub>1</sub>. This would enable us to be sure that our potentiometers were linear, and to save time during analysis by setting R<sub>1</sub> and R<sub>2</sub> at the approximate potential required for electrolysis of each substance. These data were obtained by connecting a vacuum tube voltmeter across j<sub>1</sub> and j<sub>2</sub>.

### Experimental

#### Materials:

Pure mercury;

Electrolysis vessel of about 10 ml. capacity;

Saturated KCl-calomel electrode;

Capillary—pulled from thermometer tubing;

70 cm. length of Tygon tubing;

Leveling bulb;

2 agar-saturated KCl salt bridges;

Self-stopping hydrogen generator;

0.2% gelatin;

Normal potassium chloride solution;

0.01 Molar cadmium chloride solution;

0.01 Molar zinc chloride solution.

The electrodes and electrolysis vessels are connected by means of the salt bridges. The drop time of the mercury through the capillary should be adjusted so that from 3 to 6 seconds elapse between drops when the mercury column is about 65 cm. high.

(Continued on Page 102)

# The Cook is a Chemist

• By Students of Mount Mercy College

MOUNT MERCY COLLEGE, PITTSBURGH 13, PENNSYLVANIA

*This is the script for a radio program presented by Misses Shirley Popich, Theresa Iapalucci, Mary Agnes Horn and Anita June Eaton over Station WJAS, Pittsburgh. The program was one of a series entitled A WOMAN'S WORLD.*

*The young ladies, who participated in the program, are students in the chemistry department of Mount Mercy College. The program was presented in an attempt to popularize science.*

SHIRLEY—Hey, what smells so good, Mary Agnes?

MARY AGNES—Oh, hi kids! That's my cake in the oven and while it's baking, I'm trying to study for that chemistry test tomorrow. Honestly, I don't see why a home economics major has to take chemistry. After all, I'm going to be cooking in a kitchen on a stove, not in a lab over a bunsen burner!

SHIRLEY—But, Mary Agnes, do you really think that you don't need chemistry in the kitchen?

MARY AGNES—Why sure, Shirley, who needs chemistry to cook?

SHIRLEY—O.K., Mary Agnes, let's take an example. What do you think is the easiest thing to cook?

MARY AGNES—Next to boiling water, I'd say an egg.

SHIRLEY—And you really think that's easy?

MARY AGNES—Sure, and you don't need chemistry. I just have to know the proper method for cooking an egg—I don't need a formula or a test tube for that!

TERRY—Well, what do you need to cook an egg?

MARY AGNES—What a silly question, Terry. If you ever cooked one you know you put the egg in a pan of cold water and heat for a few minutes.

SHIRLEY—And how do you know when an egg is cooked, Mary Agnes?

MARY AGNES—Oh, anyone knows the difference between a raw and a cooked egg. The raw egg is a thick liquid, while the cooked egg is a solid.

SHIRLEY—That's right. Now, why did the egg turn solid?

MARY AGNES—Well, it just does. Say, you mean there is chemistry involved in that?

SHIRLEY—This change from a liquid to a solid is as much a chemical change as the ones which take place in your test tube when you have chemistry lab on Tuesday afternoon.

MARY AGNES—Well, Shirley, I never thought of an egg as being a chemical! When someone says egg, I just think of a shell, a white and a yolk.

TERRY—Let's ignore the shell since it isn't edible. But take that white. What is it if not a combination of chemicals? I'm sure you have discussed the protein, albumin, in your nutrition classes.

MARY AGNES—Yes, our teacher did say something about there being more protein in the egg white than in the egg yolk.

TERRY—That's true. And this albumin which makes up most of the egg white is a chemical.

JUNE—And that's not all, Mary Agnes. In the same way, the yolk is made up of chemicals like fats and fat-like substances, minerals and vitamins. Since the greater part of the yolk is fat, it has a higher calorie content than the white.

MARY AGNES—Then, would you suggest the next time I go on a diet, I could eat the white of the egg and not the yolk and therefore cut down on my calories?

JUNE—Well, you could do that, but since both the yolk and the white are so nutritious, it would be better to eat the whole egg and cut down on cakes like the one you have in the oven!

MARY AGNES—Hey, hey now. I thought you kids were going to teach me about cooking an egg and not about counting my calories. You've told me what chemicals are in an egg, but you haven't explained what happens to them when you cook an egg. Doesn't a raw egg consist of the same chemicals as a cooked one?

TERRY—Yes, Mary Agnes, it does, in a way, but cooking an egg causes chemical changes. The albumin in the egg white, which I mentioned before, thickens when it is heated and it is this thickening which causes the egg to become hard. Your chemistry instructor will refer to this thickening as coagulation.

JUNE—And the yolk, too, is changed when the egg is cooked. Some fatty substances break down into fatty acids, the gas carbon dioxide is given off and through these changes, the egg is made, on the whole, more digestible.

MARY AGNES—O.K., so I agree that an egg is composed of chemicals and goes through chemical changes when cooked, but how does this affect my cooking? Do you really think it's necessary for me to know a lot of chemistry if I know the proper methods of cooking? Will knowing the chemistry behind it make my egg taste better?

SHIRLEY—That's just our point, Mary Agnes. It's through your chemistry that you'll know the method which will give you the best results and *why*.



MARY AGNES—For example!

JUNE—For example. Do you remember the first week of Home Economics class in junior high when you were learning to cook eggs? I'm sure someone in the class didn't follow directions and probably cooked her egg for about fifteen minutes in boiling water.

MARY AGNES—Yes, I remember. It seems our class made quite a few blunders in the beginning.

JUNE—Well, can you remember what that egg looked like?

MARY AGNES—It seems to me it was *rather* hard.

JUNE—You bet it was! The white was very tough and rubbery and the yolk had a dull, yellow color. Now we know through chemistry that the white thickens at about 150° F. and the yolk at 158° F. Since that egg was cooked in boiling water at a temperature of 212° F., it's plain to see that this temperature was too high and that's why your egg was so hard.

SHIRLEY—And another thing, Mary Agnes. I didn't see the egg and you can't remember, but I'll bet there was a green discoloration between the white and the yolk!

MARY AGNES—Well, yes, I've seen that green ring in eggs! Does chemistry explain that, too?

SHIRLEY—Yes, it does, in this way. A chemical reaction took place because the egg was heated to too high a temperature for too long a time. The protein in the egg white contains sulfur and when heated, the gas, hydrogen sulfide, is formed. This reacts with iron in the egg yolk to form the green ring of ferrous sulfide.

MARY AGNES—Well, I see what you mean now. Chemistry can show that cooking an egg in boiling water for fifteen minutes isn't the best method to use!

TERRY—And chemistry also adds that the best method is to cook the egg in water which is just below the boiling point. You do this by boiling your water and then adjusting the heat so that your water simmers. Thus, the temperature won't be too high and the egg will have a firm but tender white, a firm but not rubbery yolk, and no green discoloration.

MARY AGNES—I guess I'll have to agree that chemistry can be of some use in Home Economics.

SHIRLEY—But that's not all. You need your chemistry to tell you how to cook as well as why.

MARY AGNES—What do you mean, why?

SHIRLEY—Exactly that—why do you cook?

MARY AGNES—To have something to eat. Don't tell me that's chemistry too!

SHIRLEY—*What else* should I say? You cook to eat and nourish yourself and that process is again a chemical one. A cooked egg is more digestible than a

raw one. In fact, you can prove this by putting some raw egg white in one glass and some cooked egg white in another. Then add a synthetic gastric juice which is just like the one which is in your stomach. The cooked egg white dissolves much faster than the raw. In your stomach the same reaction takes place. This test proves a cooked egg is more digestible than a raw one.

MARY AGNES—Gee, I read that in my foods book, but I can see it's even more apparent to you kids since you did that experiment in the lab. I understand cooking an egg involves quite some chemistry, but that does not show that chemistry and cooking are always related. Am I perhaps doing laboratory work in the kitchen and do not know it?

TERRY—Sure, remember you have a cake in the oven. What did you use in making it?

MARY AGNES—Eggs, of course, cake flour, baking powder, sugar, milk, and vanilla are the basic things I used.

JUNE—We can't take care of all that right now. We have to go to class in a few minutes. Each of these things is composed of chemicals and reacts in baking the cake. Which one would you like to hear about?

MARY AGNES—Eenie, meenie, minie, mo.—I pick baking powder.

TERRY—Oh, thank you, you make it easy for us for that is a mixture of pure chemicals, that is, sodium bicarbonate, an acid, and starch.

MARY AGNES—I'll take your word for it. How about a little more detail.

SHIRLEY—The chemist would classify sodium bicarbonate as a salt. You know it very well as baking soda.

MARY AGNES—But isn't baking soda the same as baking powder?

TERRY—Oh, no, it's merely one part of it. An important one, though. To be effective in baking powder it has to get some acid action.

MARY AGNES—What specific chemical is this acid?

JUNE—There might be tartaric acid in it or so-called acid salt like calcium acid phosphate. These acid salts are the only ingredients that vary in baking powder since all baking powders contain sodium bicarbonate and starch.

MARY AGNES—Trust chemists to complicate things. We have now at least three components of baking powder: starch, baking soda, and acid salt. What are they all for?

SHIRLEY—It seems to me that you know the answer. What are you looking for when you buy baking powder?

MARY AGNES—That depends on the use. I might buy a fast or slow-acting one. When we first started baking cakes we always chose a slow-acting baking

powder because we were so slow in mixing the ingredients and with this type the batter wouldn't rise before we got it into the oven. Now, I prefer those which act a little faster.

TERRY—That's an important point. Whether it is slow or fast, what is this action?

MARY AGNES—I told you—the raising of the batter. How about a little more information?

TERRY—The acid salt reacts with the sodium bicarbonate and the gas, carbon dioxide, is produced. This is what causes the cake to rise—the gas is between the solid portions of the cake and literally lifts it up.

JUNE—There is more to it. When the batter is mixed with the baking powder, it rises slowly right away but much faster once it is in the oven.

MARY AGNES—In other words the temperature has something to do with it. I know that heat speeds up all reactions.

TERRY—That's not all. You know all gases expand quickly with increasing temperatures. A bubble of carbon dioxide will double its size if it is heated from room temperature to that of the oven. That's why the batter rises slowly first and rapidly in the oven.

MARY AGNES—All right, all right. That is what I guess you would call the general reaction, but I told you there are slow and fast-acting baking powders. What causes the difference in speed if the chemical reaction is the same?

JUNE—That is where the acid salt comes in.

SHIRLEY—Don't forget the water has something to do with it also.

TERRY—Naturally, but let's face one question at a time. The carbon dioxide which raises the batter comes from the baking soda. We need an acid action to produce it and get it from tartaric acid or some other acid salt.

MARY AGNES—I heard they are in baking powder. Why don't they react until they are in the batter?

TERRY—Because they are solid. Generally only liquids react. So we need the moisture from the milk and other materials in the batter to dissolve them and start the reaction.

MARY AGNES—You still haven't told me what causes the difference in speed of the baking powders.

JUNE—Each of these acid salts is affected differently by heat and moisture.

MARY AGNES—Explain, please.

TERRY—The tartrate baking powder is called single acting because it only needs moisture to start producing carbon dioxide. It causes the batter to rise a good bit before it is put into the oven because once moisture has been added the temperature of the room is sufficient to start the batter to rise.

MARY AGNES—That requires quick action on the part of the cook to get all the ingredients mixed and the batter in the oven before all that gas which is

going to cause the cake to rise escapes. I prefer the slow-acting type. What is in that?

JUNE—For instance, calcium acid phosphate. It takes a little longer to dissolve and more heat is needed to produce carbon dioxide. So your batter doesn't rise as much before it is put in the oven.

TERRY—The best baking powder uses a mixture of two acid salts. They need a great deal more heat before they release carbon dioxide and so all the gas won't escape from the batter before it is brought to a high temperature in the oven. A higher cake results.

SHIRLEY—This type of baking powder is called double-acting because it won't release carbon dioxide until both heat and moisture are used.

MARY AGNES—Now we have accounted for the baking soda and the acid salts. What part does starch take in the reaction of baking powder?

SHIRLEY—Starch takes a negative part in the reaction since it keeps the sodium bicarbonate and the acid salts from reacting before they are put in the batter.

MARY AGNES—You mean starch is kind of a referee keeping the fighters apart before the bout?

TERRY—Yes, and no. Moisture causes these two chemicals to react. Starch is added to absorb the moisture so that it will have no effect on the two substances.

MARY AGNES—I guess "Keep your powder dry" applies to the non-warfare type too.

JUNE—Starch is also used as a filler. The amount used is limited by federal law so that it is certain that a sufficient amount of the ingredients that actually react are present.

MARY AGNES—That's interesting. Just imagine the government worries about my cake.

SHIRLEY—The Food and Drug Administration does more for you. Baking powders are also tested for the amount of carbon dioxide given off. Federal Law says that enough sodium bicarbonate and acid salts must be present to release 12% carbon dioxide.

JUNE—I pity those who had to make cakes before baking powder was used.

TERRY—You know, they employed yeast and sugar to get the same carbon dioxide. That takes a little more time to do—and to understand its chemistry.

MARY AGNES—Let's not go into that now. I can see already how closely related chemistry and Home Economics are. In fact, you may have solved my problem of what to choose as my second minor.

SHIRLEY—I don't know if we have solved your problem, but I'm glad you have a different outlook on your chemistry course now.

JUNE—Say, kids, it's 1:30 and we'd better be getting up to the lab if we want to be out in time for dinner at 6:00. See you, Mary Agnes.

MARY AGNES—Bye, kids. ●

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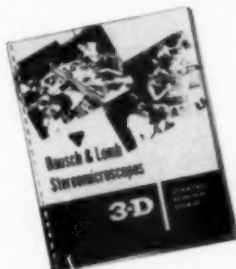
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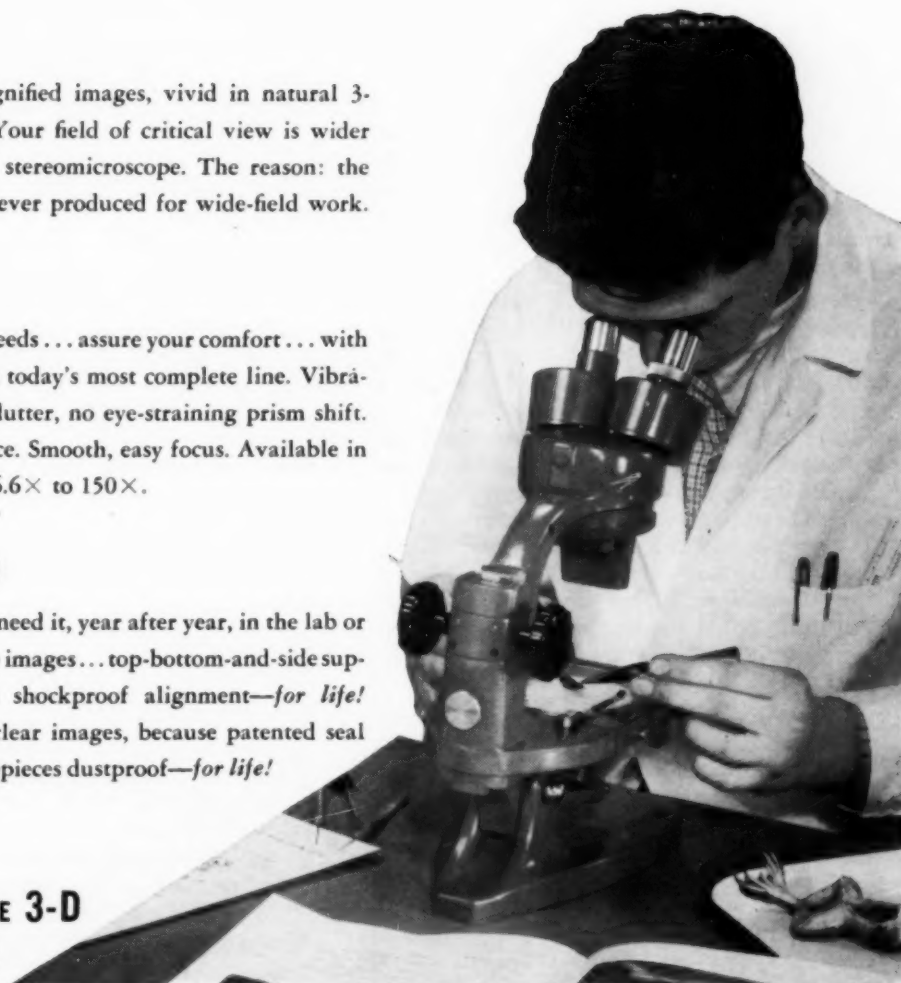
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# The Origin of Heavy Hydrocarbons

• By **J. D. Haseman, Ph.D.**, (Columbia University)

LINTON, INDIANA

*Petroleum is now believed to have been formed from the remains of marine organisms. Most theories of the origin of petroleum demand centuries for the formation of petroleum.*

*This article describes a series of experiments designed to explain one possible mechanism by which hydrocarbons could be formed.*

## Introduction

Plant lipids, especially those found in pelagic and other microflora are believed by some to have been the source-material of petroleum. Chemists can synthesize hydrocarbons from lipids, coal, cellulose, vegetable and animal fats and oils, starches, sugars, and almost any carbon containing material.

In the natural decomposition of plant material cellulose and lignin are usually decomposed more slowly than sugars, starches, proteins and fats. It has been observed, however, that bacteria, when fed the proper diet of phosphorous and nitrogen, hasten the breakdown of humus, and that the bacteria in the paunch of the cow readily break down cellulose into simpler carbohydrates. It is definitely known that certain humic acids are resistant to bacterial and geochemical action. This is true of the azo humic acid found in Miocene clay near Cassel, Germany, and that developed by the author in Florida. The question to be answered is, can nature convert plant-lipids into a source-material of petroleum that neither bacterial nor geochemical action can destroy?

The source-material of petroleum must be easily liquified, concentrated and precipitated, and not readily destroyed by bacterial nor other action. In 1917, a new viewpoint of the origin of petroleum resulted from the discovery of a slightly oxidized asphalt in the vandyke brown hardpan of Florida. A schooner's mast with a copper lag screw, found beneath the hardpan, indicated that the deposit was of historical age. Short papers on this discovery were published in the AAPG Bulletin in 1921<sup>1</sup> and 1930<sup>2</sup>. The author found that nature started with plant cellulose, mainly of fresh-water origin, and made (and was still making) alkali water-soluble humates, precipitated them in brackish water, and then made the vandyke brown, however, a few small patches of asphalt, that had been synthesized *in situ* without the help of extra heat or pressure, were found.

From 1941 to 1944 the author performed some tests with fresh water plants mixed with radioactive black sand minerals of Florida, activated carbon of the color precipitating form, activated bentonite from Death Valley, certain trace or other minerals found in oil

sands, and salt water. No extra heat or pressure were used. Some heavy hydrocarbons were produced. The materials used in these tests had been previously examined for waxes oftentimes found in soils, sands, minerals, etc., but no paraffin or other heavy hydrocarbons were found.

There were above normal local concentrations of radioactive minerals around the small patches found in the Florida vandyke hardpan which I tried to duplicate in my tests. Such concentrations of radioactive minerals can slow down or prevent the total bacterial destruction of celluloses. It produces some ionization which seems to aid the geochemical precipitation of water-soluble humic acid carbohydrates even in the absence of salt water.

## Tests

The following tests were made in loosely sealed Mason jars. They were conducted in a dark basement at an average temperature of 70° F. for three years. All tests had only approximately the same amount of wet plants taken from a coal-stripper pond. The plants were water grass, cat-tail, myriophyllum, duck-weed, algae, and some diatoms. The plants were neither dried nor ground, in order to preserve their natural bacteria, fungi, protozoa, etc.

### Test Number 1.

Three tablespoons of plants were mixed in a quart of sandy mud and water from the stripper pond. The water was quite hard and the sandy mud had some iron oxides which had been washed into the pond from the coal shales. This test had only normal radioactivity and normal traces of activated carbon and silica.

### Test Number 2.

Three tablespoons of plants, one tablespoon of number 6 coal-roll minerals, two tablespoons of filtrol or activated bentonite, two tablespoons of norite or activated carbon of the color precipitating form, one tablespoon of wettable sulfur, one tablespoon of spray lime, eight tablespoons of sodium chloride and the jar filled with water.

### Test Number 3.

Three tablespoons of plants, one tablespoon of activated carbons, one tablespoon of activated bentonite, two tablespoons of salt, one pint of radioactive Vero Beach black sand, one-half pint of washed sand, and the jar filled with water. This test had above normal Florida concentration of radioactive minerals.

### Test Number 4.

Three tablespoons of plants mixed in a quart of radioactive black sand minerals and filled with water. This test had much more than the normal concentration of radioactive soil minerals.

At first all the jars were sealed tightly to prevent atmospheric effects. After several days the lid of the number one control jar was bulging due to gas pressure. I then loosely sealed all four jars as I wanted the same atmospheric effects for all. At first the gases from jar one were amply produced and easily collected to make sure that only methane and carbon dioxide were produced.

### Results

After one year the following results were observed:

*Control jar* (number one) which had produced considerable carbon dioxide and methane contained yellow oxide of iron. It contained no heavy hydrocarbons and did not yield a precipitate with aluminum chloride (a test used in chemical oil-surveying work.)

*Jars 2, 3, and 4* produced neither methane nor carbon dioxide, nor any other detectable gas. All three produced some heavy hydrocarbons, gave a little white precipitate with aluminum chloride, and showed some yellow coloring matter not found in the control jar. The iron content of these jars was black—no yellow oxide of iron was present. In these jars iron was oxidized while in the control jar iron oxides were reduced.

After three years the jars were more fully examined using differential solvents suggested by Dr. Rees of the Illinois survey. Petroleum ether, carbon tetrachloride, carbon disulfide, and diethyl ether were used. The sulfur dissolved by the carbon disulfide had to be removed after the extraction.

The control jar still had traces of carbon dioxide and methane. It did not yield heavy hydrocarbons, nor red and yellow coloring matter, nor vandyke brown, and did not precipitate with aluminum chloride. (The traces of methane and carbon dioxide were held physically in the water, sandy mud, and plant remains. The bacterial activity had ceased.)

*Jars 3, 2, and 4* in this order of quantity yielded paraffin waxes soluble in all the solvents used.

The waxes were faintly yellowish in color. Almost one-fourth of this wax was soluble in alcohol and was identified as ceresin. The tests yielded red and yellow coloring matter, almost if not, identical with those in oils. The ethereal extract was extracted with caustic soda but no vandyke brown was made. No light hydrocarbons were detected, but the extracted waxes did have a petroleum-like odor. Almost one gram of paraffin and almost one-quarter gram of ceresin were obtained from all three samples.

### Discussion

The above tests were set up under as natural conditions as possible. They were based upon the materials that nature used in making the small thin patches of asphalt found in the Florida vandyke brown hardpan. They were designed to utilize some of the extra catalytic energies that nature put into fullers earth when it changed an inert clay into one that would precipitate the coloring matter in oils. However, I could not simulate the natural movements of liquids that nature

used to remove prohibitory materials that stop catalytic reactions. Nor, did I expect a complete transformation of the cellulose through humic acid into heavy hydrocarbons. The stripper pond plants were cut into small pieces and kept in pond water until used. Naturally, neither the dry weights nor the actual absolute analyses of the constituents in the three tablespoons of wet pieces of plants were 100 per cent identical. And the amount of cellulose in each test if converted 100 per cent into heavy hydrocarbons alone, was not expected to yield more than 1 or 2 grams. The starches, sugars, lipids and proteins in such plants as used if converted at all would not have yielded much more than traces. And as the lignins are extremely difficult to liquefy under the conditions of the tests even by the use of strong caustic soda, neither Beryl (in a herein quoted letter) nor the writer have found the lignins to be converted into hydrocarbons. Hence if I could get one or two grams of heavy hydrocarbons out of nine tablespoons of wet green plants, it necessarily would be via the cellulose humic acid route as in the Florida vandyke brown asphalt. I somehow expected to get asphalt instead of paraffin even though the stripper plants and other conditions were not identical with the Florida conditions. I feel certain that sea salt water would have been much better than only table salt as magnesium and other trace elements in sea water are known to be necessary regulatory ions in a host of catalytic reactions.

The fact that the control test had yellow iron oxides is significant since its organic matter was converted mostly into marsh gas and carbon dioxide with some iron reduction. The other three tests yielded no marsh gas and no carbon dioxide and had increased iron oxidation.

The natural change of pyrite and marcossite into sulfuric acid and iron oxides and iron alums and the effects of this change on silica and clay are well known. Logan<sup>3</sup> presented some interesting experimental tests with certain bacterial actions in the formation of Indianite clay deposits. My test number two had other iron minerals and tests number 3 and number 4 had ilmenite and 22 other minerals, which minerals were identified for the author by Moses and Parson. As no freed oxygen and carbon dioxide were observed, the oxygen removed from the humic acid carbohydrates may have, at least in part, combined with the iron present.

The tests number 2, number 3, and number 4, after ethereal and caustic soda extraction still contained cellulose in varying amounts, and all had considerable dark lignitic-like material. It was evident that the activated catalytic and other changes produced inhibitory materials that stopped the conversion, quite like the inhibition caused by caustic soda freed during color precipitation by fullers earth. Hence my tests evidently can have a better set-up to either combine with or wash out the inhibitory materials.

The late Professor E. Beryl<sup>4</sup> at Carnegie Tech did a lot of laboratory research along this line. He used

higher heats and pressures than either I or nature in the vandyke ore used. His chief difference is in explaining how the oxygen is removed from humic acids and hydrogen is utilized in this conversion process. So I trust his letter will be both interesting and illuminating.

Department of Chemistry  
Carnegie Institute of Technology  
Pittsburgh, Pa.  
May 7, 1940

Dear Haseman:

I am very pleased to have your letter of May 2. I have read your publications in the Bulletin of the AAPG 1921 and 1930. Our views come close to yours. What we have done is to start either from complex carbohydrate-like cellulose, or less complex carbohydrates like algae or simple carbohydrates like sucrose or dextrose and we have produced from these materials, according to freely chosen conditions, either an intermediate product which we call proto-product which is the parent materials for asphalts and oils, or we could produce non-caking and caking coals with exactly the same properties as we find in nature. I do not think that there is much catalytic action in this conversion of parent material into the final product. The energy is given by a rather strong heat which is observed by this process of a kind of intramolecular combustion. The energy which is produced by this intramolecular combustion whereby the oxygen content of the parent material decreases from 50 per cent to 0 per cent allows the carrying out of a great number of endothermic reactions so that now the very complex nature of this liquid, semi-liquid and solid fuel can be somewhat explained.

We have found that in many experiments lignin and its derivatives gave so little liquid transformation products that we do not believe lignin humic acids are to be considered as important materials. On the other hand the carbohydrate humic acids are very reactive and can be transformed rather easily into asphaltic materials or bituminous-like coals.

I would be extremely glad if I could get some of the type which you consider as parent material for asphalts and oils. We have already made some studies to find if there is a possible way to distinguish easily between lignin humic acids and cellulose humic acids. Up to now we have not had great success but I hope further work will shed some light on this important question.

I am sending you with great pleasure a paper on the formation of oil. My talk before the AAPG in Chicago a couple of weeks ago contained more material because since this paper was read in Oklahoma in the fall of 1937, other interesting facts and results could be obtained. I hope the Chicago paper can be published rather soon. Then I will have the pleasure of sending it to you.

Yours very truly,

E. Beryl

The writer observed no intramolecular combustion, as the term is ordinarily used, in the tests that yielded heavy hydrocarbons. There need be no rather high heat when oxygen is removed catalytically. The writer's unpublished special infrared absorption spectra of silica, its activated gel and its special spent gel after 160 reuses now show that there is a necessary  $950\text{ cm}^{-1}$  band of OH that disappears in the spent gel when it returns to its inert state. So the extra distorted elec-

trons shells that bond the silica and special OH groups to other macromolecules evidently free their activation energies of 3000 to 4200 angstroms. The reacting ultraviolet light produces the necessary H and OH groups also, under special conditions two of these OH groups or ions can make hydrogen peroxide and thus produce oxygen ions. These hydrogen, hydroxyl and oxygen ions are the basis of all low temperature and pressure activated carbon and silica catalytic reactions. Before these data can be interpreted comparative studies of the infrared spectra of known and possibly related compounds must be made.

Petroleum geologists know humic acids to be slightly soluble in water, but some do not know that their alkali salts are readily soluble in water. These soluble salts can be carried long distances and then be concentrated in sediments by weak acid salt precipitation.

Some also do not know that humic acids in nature can be made into azo-humic acids and these in turn will make azo-silico humic acids which can prepare crystalline silica that can readily be made into the activated state. There can be no doubt but that the energies due to the activation of carbon and silica do play a basic part in the making of heavy hydrocarbons out of carbohydrate humic acids in special environmental conditions and in presence of necessary regulatory materials.

#### Summary

1. The energies freed by slight increases above normal in local concentrations of radioactive materials, activated carbons, and activated silicas in sediments are important in the genesis of heavy hydrocarbons in special environments that contain the necessary regulatory materials.
2. Heavy hydrocarbons can be made catalytically from plant cellulose without the aid of extra heat and pressure.
3. Nature first probably made the heavy hydrocarbons and then later made the lighter fractions of petroleum.
4. Crude petroleum deposits have much higher temperatures and pressures than used in vandyke brown ore asphalt or the above tests.
5. The bulk of petroleum was probably derived from plant celluloses that were liquefied as carbohydrate humic acids either made or carried to and precipitated in sediments that had at least sulfur, iron, manganese, magnesium, calcium, trace minerals, some silica and argillaceous materials, salt water, and more or less than normal local concentrations of radioactive minerals and activated carbons and silicas.
6. Activated geochemical catalytic reactions including some bacterial catalytic activities and their currents of action which make measurable changes of magnetism from the surrounding area, in connection with the increase of radioactive and activated carbons and silicas were also important environmental factors. At least in the beginning all bacterial and fungicidal ac-



tivities did not cease. And of course movements of liquids are also factors.

7. Humic acid origin of asphalt now definitely seems to be the most plausible theory of accumulating, preserving and of transforming organic matter in special marine geosynclinal sediments into hydrocarbons yet propounded.

8. It now seems possible with further experimental work to get a better mix, a better yield and a continuous process for the conversion of waste celluloses into hydrocarbons. ●

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## Project in Polarography

(Continued from Page 93)

Many polarographic experiments and determinations are described in the literature. One of these is an interesting study of the effect of concentration on the polarographic wave height of either zinc or cadmium chloride. Using 100 ml. volumetric flasks, a series of solutions of cadmium chloride is prepared. In each flask are placed 20 ml. of 1 Molar potassium chloride, 2.5 ml. of 0.2% gelatin solution and the following quantities of 0.01 Molar cadmium chloride: (1) none, (2) 2 ml., (3) 5 ml., (4) 10 ml., (5) 15 ml., (6) 20 ml., (7) 25 ml. Each is diluted to the 100 ml. mark. A sufficient volume of the first solution is transferred to the electrolysis cell, hydrogen is bubbled through to remove dissolved oxygen and electrolysis carried out between  $-0.4$  and  $0.8$  volt. This process is repeated for each solution. The applied voltage is plotted against the galvanometer readings. By preparing an additional solution of "unknown" concentration it is possible to perform a quantitative analysis from the data obtained.

### Precautions

The ends of the capillary must be protected from dust. This is accomplished by starting and stopping the flow of mercury only while the capillary is immersed in clean distilled water.

It is advisable to place a large pan containing water under the mercury vessels to catch spilled mercury.

The capillary should be permanently fixed in position, since altering its position effects results.

Fresh gelatin must be used.

Salt bridges should be free from air bubbles.

Temperatures must be allowed to reach equilibrium before electrolysis is attempted.

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## Lithium---Miracle Element

(Continued from Page 85)

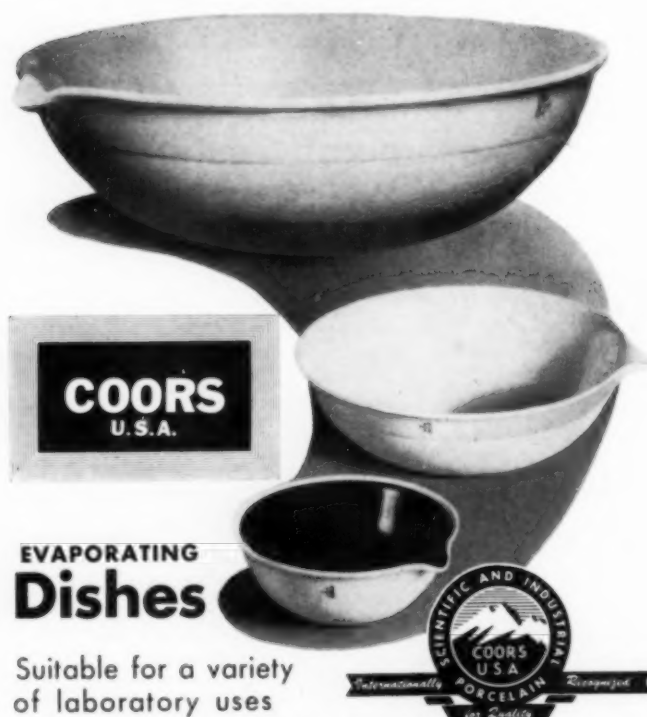
In ceramics, a number of companies are working on the development of low-fired porcelain enamels for the coating of aluminum architectural panels. Enamelled aluminum facing on office structures would result in great savings in weight of supporting steel members, at the same time giving the metal the durability of finish and weatherability which is needed.

De-icing of aircraft both on the ground and in flight is another problem currently under study.

Here, then, we have an infant industry based on an element known to man for over fifty years. It is a fine example of what can be accomplished in a scientific field through initiative and diligent research. To a young man embarking on a scientific career, the study of lithium presents the possibilities of interesting work and ample rewards. ●

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## The Dawn Of The Universe

*In an address to the Pontifical Academy of Science on November 22, 1951, Pope Pius XII discussed the problem of modern science and the existence of God. Every Catholic who is interested in science should study this document. The following excerpt is presented to give an idea of its contents.*

First of all, to quote some figures—which aim at nothing else than to give an order of magnitude fixing the dawn of our universe, that is to say its beginning in time—science has at its disposal various means, each of which is more or less independent from the other, although all converge. We point them out briefly:

### 1. RECESSION OF THE SPIRAL NEBULAE OR GALAXIES.

The examination of various spiral nebulae, especially as carried out by Edwin W. Hubble at the Mount Wilson Observatory, has led to the significant conclusion, presented with all due reservations that these distant systems of galaxies tend to move away from one another with such velocity that, in the space of 1,300 million years, the distance between such spiral nebulae is doubled. If we look back into the past at the time required for this process of the "Expanding Universe," it follows that, from one to ten million

years ago, the matter of the spiral nebulae was compressed into a relatively restricted space, at the time the cosmic processes had their beginning.

### 2. THE AGE OF THE SOLID CRUST OF THE EARTH.

To calculate the age of original radioactive substances, very approximate data are taken from the transformation of the isotope of uranium 238 into an isotope of lead (RaG), or an isotope of uranium 235 into actinium D (AcD), and the isotope of thorium D (ThD). The mass of helium thereby formed can serve as a means of control. This leads to the conclusion that the average age of the oldest minerals is at most 5 billion years.

### 3. THE AGE OF METEORITES.

The preceding method adopted to determine the age of meteorites has led to practically the same figure of 5 billion years. This conclusion assumes special importance from the fact that today the inter-stellar origin of meteorites is generally admitted by all.

### 4. THE STABILITY OF THE SYSTEMS OF DOUBLE STARS AND STARRY MASSES.

The oscillations of gravitation between these systems, as also the attrition resulting from tides, again limit their stability within a period of from 5 to 10 billion years.

Although these figures may seem astounding, nevertheless, even to the simplest of the faithful, they bring no new or different concept from the one they learned in the opening words of Genesis: "In the beginning . . .," that is to say, at the beginning of things in time. The figures we have quoted clothe these words in a concrete and almost mathematical expression, while from them there springs forth a new source of consolation for those who share the esteem of the Apostle for that divinely inspired Scripture, which is always useful "for teaching, for reproving, for correcting, for instructing" (2 Tim., 3, 16).

### THE STATE AND QUALITY OF ORIGINAL MATTER

In addition to the question of the age of the cosmos, scholars have, with similar earnestness and liberty of research and verification, turned their daring genius to the other problem which has already been mentioned and which is certainly more difficult, concerning the state and quality of primitive matter.

According to the theories serving as their basis, the relative calculations differ in no small degree from one another. Nevertheless, scientists agree in holding that not only the mass but also the density, pressure and temperature of matter must have reached absolutely enormous proportions, as can be seen from the recent work of A. Unsold, director of the Observatory of Kiel (*Kernphysik und Kosmologie*, in the *Zeitschrift für Astrophysik*, 24, B. 1948, pag. 278-305).

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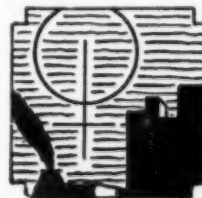
Rightly on the other hand, does the mind in its eagerness for truth insist on asking how matter reached this state, which is so unlike anything found in our own everyday experience, and it also wants to know what went before it. In vain would we seek an answer in natural science, which declares honestly that it finds itself face to face with an insoluble enigma. It is true that such a question would demand too much of natural science as such. But it also is certain that the human mind trained in philosophical meditation penetrates more deeply into this problem.

It is undeniable that when a mind enlightened and enriched with modern scientific knowledge weighs this problem calmly, it feels drawn to break through the circle of completely independent or autochthonous matter, whether uncreated or self-created, and to ascend to a creating Spirit. With the same clear and critical look with which it examines and passes judgment on facts, it perceives and recognizes the work of creative omnipotence, whose power, set in motion by the mighty "Fiat" pronounced billions of years ago by the Creating Spirit, spread out over the universe, calling into existence with a gesture of generous love matter bursting with energy. In fact, it would seem that present-day science, with one sweeping step back across millions

of centuries, has succeeded in bearing witness to that primordial "Fiat lux" uttered at the moment when, along with matter, there burst forth from nothing a sea of light and radiation, while the particles of chemical elements split and formed into millions of galaxies.

#### NO ABSOLUTE PROOF FROM SCIENCE

It is quite true that the facts established up to the present time are not an absolute proof of creation in time, as are the proofs drawn from metaphysics and Revelation in what concerns simple creation, or those found on Revelation if there be question of creation in time. The pertinent facts of the natural sciences, to which we have referred, are awaiting still further research and confirmation, and the theories founded on them are in need of further development and proof, before they can provide a sure foundation for arguments which, of themselves, are outside the proper sphere of the natural sciences.



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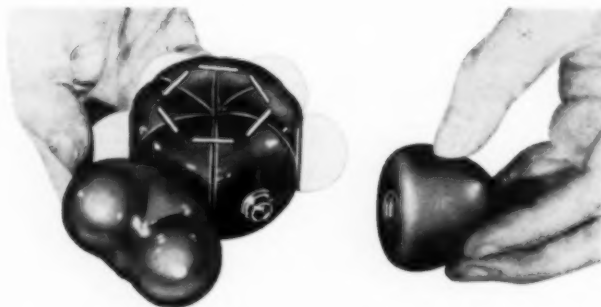
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## Health Careers

Released September 15th, a new film titled *Health Careers* adds another resource to the nationwide Health Careers Project sponsored by the National Health Council. Like the Health Careers Guidebook and its supporting publications, the film is nationally available without charge for school, community, and television use. In addition to this loan arrangement, prints may be secured at a nominal fee as explained below.

A documentary film, *Health Careers* introduces today's youth—their parents, teachers and counselors, and the general public—to all kinds of career opportunities in health. Deliberately avoiding the pitfall of telling teen-agers more than they want to know, the film is a question-raiser designed to stimulate discussion. Its preview of who-what-why-and-where in health work literally opens new horizons. Warm and intimate glimpses of these "helping" professions show how they serve the community—its families, and their children. As one counselor comments, the film "speaks in a low key but with deep conviction". Developed with the guidance of 20 consultants representing secondary education and school counseling services, as well as the health professions, the story line reflects the keynote of the Health Careers Project—Partners for Health.

With this human interest focus, the film covers health work in hospitals, health departments, schools, industry, private practice, and community agencies. High school students—both those who appear in the film and those who will be in its nationwide audience—see actual health workers doing their actual jobs. They discover partners for health not only in such familiar settings as the physician's or dentist's office and the hospital room, but also in places where teen-agers might not look for health services—a school cafeteria, a corner drugstore, a research laboratory, a veterinary hospital. Both picture and narrative keep a balanced emphasis—on physical and mental health; on working with the sick and the well; on the wide range of requirements from little or no special training to years of graduate study; on individual choice and "opportunities unlimited".

In addition to school and community showings, the film is suitable, and has been cleared, for TV showings. Intentionally flexible, it not only tells a complete story with a wide appeal, but also has the added advantage of adapting to a wide range of combination uses:

- as a counseling tool in secondary schools, for group counseling, career-information activities, assembly programs;
- as a teaching aid in health, social study, and occupational classes;
- as the core of a half-hour TV program with live participants highlighting the local Health Careers story;

(Continued on Page 116)





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## Boyce-Thompson Institute

*(Continued from Page 81)*

are designed to kill grass and leave strawberries for instance, healthy. There is even a herbicide designed to kill crabgrass but not perennial lawn grasses.

On the test farm at Boyce Thompson, one of the research problems is to find the point at which herbicides are most selective. A 20 percent solution of a certain herbicide applied to a row of corn might kill all the weeds, but also kill the corn. A 10 percent solution might leave the corn untouched but kill only 20 percent of the weeds. Somewhere between these points is the best concentration. Finding it is the researchers' job—a job complicated by a number of variable factors. For instance, even if the corn is initially retarded by the spray, because of the advantage of weed-free soil it may catch up to or even surpass untreated plants. Or, even if a herbicide gives good results it might work even better if applied differently, or at a different time during the growing season.

For experiments like these, the Boyce Thompson farm includes a number of plots in which long rows of different crops are planted about a foot apart. These rows are marked off to make a number of small "fields." Most of these fields are then sprayed with different herbicides, or different concentrations, or sometimes identical chemicals are applied at different stages of development. Some plots are left untreated so they can be used as "control" plots, against which the treated fields can be checked.

As the plants grow (or, sometimes, fail to grow), researchers watch and record effects. In this process, the substances that are of no value are discarded, and those that seem to be effective for one or more crops can be noted and developed further.

### Benefits to All

Through agricultural chemical research thousands of people are contributing to the welfare of millions more. To the farmer the new substances may mean the difference between a large high-quality crop, and a small unprofitable one—or even no crop at all. To the consumer they can spell the difference between plenty of food at low prices, and scarcity at high prices.

But results can't be judged in terms of direct benefits alone. Agricultural chemicals help farmers get more usable food per acre without exhausting the land.

Thus, agricultural chemicals, like those developed through the Carbide Fellowship at Boyce Thompson, are doing their part to help eliminate waste, and to conserve the human and natural resources that we have been squandering for too long. ●

### SOURCES

1. World Population and World Food Supplies.
2. Losses in Agriculture, June 1954. ARS-20-1.

## Chemistry and Uses of Lignin

(Continued from Page 91)

sistance to the action of sulfuric acid. Its function is to decrease the weight of the plate, to increase the effective charge area and to increase the effective voltage delivered by the battery at low temperatures.

Lignin or waste sulfite liquor is used as a binding material for wood fiber products and with phenol-formaldehyde resins as a laminating agent in plywood. It has been used with clay for insulating material in walls and floors<sup>20</sup>. It has been used on roads to reduce dust and it has now been shown that lignin recovered from pulping processes in powdered form may be mixed with clay and gravel and compacted by rollers to give a stabilized and semipermanent mat. Water soluble lignin, recovered from waste sulfite liquors, when added to concrete acts as an emulsifying agent and reduces amount of water required to produce a free-flowing concrete, which is claimed to have increased strength<sup>21</sup>.

The tanning properties of lignosulfonic acid have been investigated. The lignosulfonic acids are irreversibly adsorbed by the hide proteins but there is some question as to their usefulness as tanning agents. They are most satisfactory when used together with normal vegetable or synthetic tanning materials<sup>22</sup>.

Lignin and lignin products are used as fertilizers and for soil improvement<sup>23</sup>. Recently Maracorb NC (Marathon Corporation), a complex mixture of lignosulfonic and wood sugar and salts was reported to show promise in preventing cattle ketosis<sup>24</sup>. An insecticide is reported to have been made by cyanogenation of lignin sulfonic acids.

Lignosulfonic acids have been used on a laboratory scale to produce cation exchangers which were satisfactory in softening and demineralization of water<sup>25</sup>. Anion exchangers capable of absorbing high molecular substances have been prepared by condensation of alkali lignin<sup>26</sup> with organic nitrogen bases. These acids have also been used as emulsifying and dispersing agents, as protective colloids, as grinding aids and as reinforcing agents in rubber.

Useful chemicals have been prepared from lignin by hydrogenation<sup>27</sup>. Depending upon the conditions of hydrogenation the following have been obtained: 4-n-propyl cyclohexanediol-1,2; 4-n-propyl-cyclohexanol; 3-(4-hydroxy-cyclohexyl)-propanol-1; acetone, methyl ethyl ketone, methyl-n-propyl ketone, cyclopentanone, cyclohexanone, 2-methyl cyclohexanone, phenol and substituted phenols, cresol, guaiacol, catechol and substituted catechols.

Despite the various possible fields in which this abundant by-product can be used, investigation of economic methods of burning sulfite wastes still continues, indicating that no profitable, large-scale outlet for this material is yet available. Thus, there remains as a challenge for the future: (1) further research to

establish with certainty the structure of lignin and its linkage in wood; (2) development of a process for utilization of lignin which will permit profitable, large-scale industries to be built up around it. ●

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## Sponsored Teaching Aids

(Continued from Page 87)

If the United States is to continue to be regarded as the standard of technical excellence and world leadership, it becomes necessary for all Americans to assist educators wherever possible in their important task of developing the qualified young people who will inherit that leadership. The majority of the industry sponsored materials which are accepted and used effectively by educators have been developed with this objective in mind. Because of their acceptance and use it is, therefore, apparent that industry sponsored teaching aids have value to teachers—they have come of age, and will continue to be another useful tool in the teacher's work-kit. ●



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## More Dynamic Botany

*(Continued from Page 78)*

interrelationships, physical and biotic influences, barriers, the natural change in flora and fauna by successional series, food pyramids, and the wise versus unwise utilization of natural resources such as water, soil, soil substances and plants may be observed in towns as well as in fields and forests. Too, awareness of the resources of the local scene conduces intelligent political opinions concerning the utilization of the resources of the nation and of the world.

Another method of combining the utilitarian with the theoretical objectives of the general course is the selection of simple laboratory problems which require the sowing of seeds, complete care of the young plants during a specific treatment, and an explanation of the results with the probable sources of error. A greenhouse is not essential as students may care for the plants in their dormitory rooms, or at home. Learning to investigate cause or effect with adequately controlled experiments yields many concepts of scientific and philosophical value; such as those relative to life, and even the perpetuity of change. The student who has never worked with plants seems to benefit most. While discovering the fallacy of the "green thumb" myth, he is introduced to a fascinating and useful avocation. Laboratory exercises or experiments which utilize weeds and cultivated plants such as grasses, legumes, philodendrons, sanseveria, nephthitis, and the more common house plants, may increase the student's acquaintance with the plants of his community and their optimal requirements for healthful growth, concurrently with his acquiring mastery of the principles of plant function and structure.

One class in general botany sought, in addition to the regular class assignments, the plant problems of the householders of their community. From their collection, they selected problems which the instructor considered possible of solution within the term; such as, the causes of grass seed failures in one part of a lawn, of the elongated, unbranched stems of certain plants, of the sudden loss of leaves from house plants; or how to increase the rate of soil covering with certain vines, the selection of good locations for specific shrubs or trees, the designing of harmonious coloring from spring until autumn with herbaceous and woody perennials. The planning and conducting of this "research," and the discovery that similar problems had been investigated by botanists whose reliable results were easily obtained from libraries, agricultural stations, or the United States Government Printing Office, made for a most dynamic class.

With the increased tempo of urban life and with the trend toward escaping it with suburban residence, there is increased need of the presentation of the fundamental principles of botany with emphasis upon the manner in which plants may be influenced by the consumer for more abundant living. This may be accomplished through the deliberate integration of all the objectives of botany.

Certainly this should be presented in the first educative experiences with plants of pre-professional botanists, biologists and the avowed amateurs in plant culture. It gives eminence to research by botanists in universities, experiment-stations and industrial laboratories. It reduces the cleavage between the applied and pure sciences which Needham described as mere differences in the immediacy of application. It gives authoritative sources for the varied types of theoretical and practical information requested by biologists, hobbyists and home-makers. It makes unique contributions to the personal, social, economic and even the philosophical phases of the life of the average citizen, and as a result, crystallizes the place of botany in liberal education. ●

★ ★ ★ ★ ★

## Carboxymethylcellulose

(Continued from Page 89)

From Table II and Figure 1 it becomes evident that the purified sodium CMC is not homogeneous with respect to lauerometric activity as indicated by the whiteness retention assays. Furthermore, there is considerable variation between the various commercial products as would be expected from the differences in manufacture<sup>6</sup>. In general, there seems to be no correlation between D.S. as determined from the sodium analyses and whiteness retention among various fractions of the four samples. The sodium content of the fractions in a single sample increases slightly as the water content of the aqueous methanol is increased while the latter fractions exhibit somewhat lower reflectancy values. In general, the reflectancy values are somewhat higher for the sodium carboxymethylcellulose fractions extracted by 60 or 57.5% methanol than for the 65% and 55% extracts or the residue. ●

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## Developmental Lenses

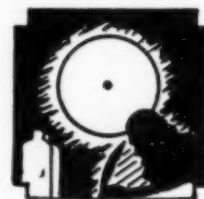
(Continued from Page 83)

adaptation, withdraw from work and suddenly dislike school.

Often around eight years of age the child becomes more "outgoing," and there occurs a marked improvement in general coordination, as well as in visual coordination. Then developmental lenses are less often necessary. At nine years of age a greater need for lenses may again occur. At ten years the child may be completely unaware of his visual difficulties and may protest that his glasses are not helping him because he can see just as clearly without them as with. At eleven years the need for help, and also awareness of that need, often increases. At all ages, the school's demands on the individual and the individual's demands on himself will be important factors to consider in addition to the individual's visual performance. Some children manage to "get by" successfully, through the grace of a good intelligence and low school visual demands, until they reach the freshman year of college, when suddenly they find the reading load to be insupportable. Then they fail—and they are never sure why. Many who do get help with lenses in college find that after graduation they use their occupational glasses less, because they stop their educational reading.

What are the symptoms that indicate a real need for developmental glasses? It is plain that distance vision is no criterion. A more revealing indication appears when the child is unable to work at his desk for more than a short period of time without becoming restless or fidgety. He may become tense or may work too close to his page; he may turn or cock his head to view the page. He may frequently stare off into space or look out the window. He may rub his eyes or lid margins, or the conjunctivae may appear reddened. If asked about his vision he may report that the print runs together or blurs after he has been reading for a short time, or that he cannot copy from the blackboard to his desk. Headaches may also be an indication. Sometimes there are no specific symptoms other than the fact that he is a bright child but is just getting by in school.

With more and more optometrists thinking in terms of visual achievement and of vision as a complex of developed skills, glasses are coming to be used not only to correct but to safeguard. We can envision future generations of children as having a better chance of developing more effective patterns of vision. ●





# New Books

## The World of Atoms

• By J. J. G. McCUE. New York: The Ronald Press. 1956. Pp. xiii + 659. \$6.50.

This book, an introduction to physical science, was written primarily for students who do not intend to major in a science. However, it should prove suitable for beginning science majors because it would give them practice in scientific thinking early in their education.

*The World of Atoms* is not just another text of diluted physics with a smattering of chemistry; it is rather a work giving the important principles of both physics and chemistry in such a manner that the student is constantly made aware of the complementary relationship of the two sciences to each other. One of the best features of the book is the elimination of the line of separation between chemistry and physics. The author has thus accomplished, rather successfully, the goal of integration within the curriculum suggested by the Harvard Report, *General Education in a Free Society*.

Among the interesting aspects of this book are twenty-four brief biographical sketches of outstanding scientists together with their portraits. Although Mr. McCue does not propose to use the "historical approach" in teaching the physical sciences, a good deal of historical matter is included in the book.

The "Suggestions for Further Reading" at the end of a number of chapters should prove helpful for the busy instructor who has only limited time for compiling a special bibliography for a course in the physical sciences. The main criticism offered by this reviewer is that the list of readings in most cases is not up to date.

The table of contents includes the following topics: mechanics, heat, foundations of chemistry, some chemical reactions, electricity, solutions, the classification of the elements, the structure of atoms, chemical binding, the atomic nucleus.

This book should serve very satisfactorily as a text for a terminal course in the physical sciences.

Sister Mary Edward, O.S.F.  
Department of Chemistry  
Briar Cliff College  
Sioux City, Iowa

## The Preservation of Natural History Specimens

• Edited and compiled by REGINALD WAGSTAFFE and J. HAVELOCK FIDLER, PH.D. Philosophical Library, Inc. New York. 1955. Pp. 205. \$10.00.

People working in the field of Invertebrate Zoology, whether they be teachers, students, amateur naturalists, museum preparators or any other group, frequently experience the immediate need for methods for mounting or preserving a particular type of specimen. In the past, it has been difficult, often impossible, to run down such methods from widely scattered sources.

The editors of this work have accomplished the task of compiling many such techniques from many sources—



Photo by VIC KELLY

some hitherto unpublished—and organizing the information into a manual complete with illustrations, for the use of amateur and professional zoologists alike.

Part I is divided into a series of chapters beginning with the Protozoa and following along according to the usual method of classification. Methods for making permanent and temporary mounts—fixatives, stains, mounting methods, etc. are included for each major group of invertebrate animals. The chapter on the Insecta is excellent not only for the wealth of information included but also for the number of beautifully detailed illustrations.

Part II includes descriptions and illustrations of various types of apparatus and instruments used in making preparations of invertebrates. Directions are clear, concise and detailed so that even the amateur might follow them easily. This is followed by a section on reagents. The final sections of the book are devoted to directions for labelling, storage and techniques of microscopy.

Dr. Lois Gmitter  
Department of Biology  
Duquesne University

## Enjoying Health, Second Edition

• By EVELYN G. JONES. J. B. Lippencott Company. Chicago, Philadelphia, New York. 1956. Pp. 434. \$3.40.

This book presents a totally new approach to the problem of teaching health to senior high school students. It elevates health education from a dry reading course to a real living experience. This is so because the format is made up in such a way as to present a very good picture preview and suggestions for activities at the beginning of each chapter, a welcome change

from the usual method of suggesting activities after the material has been covered. The illustrations are ample and very well chosen.

I for one appreciate a book that is flexible and does not require strict adherence to the sequence prescribed in the text, and this book is flexible. The check-up tests at the end of each chapter are a valuable aid not only in checking on student's progress but also to aid the teacher in emphasizing important facts that may have been passed over too lightly. In particular I enjoyed Chapter 21 because it shows how one may improvise in taking care of a sick person. I also felt that the chapter on marriage was a very enlightening one. The supplementary material, namely, the glossary, the list of film sources, and the health library, are very comprehensive.

Robert T. Perkowski  
Health Teacher  
Mt. Oliver Junior High School  
Mt. Oliver, Pennsylvania

### Building Health, Second Edition

- By DOROTHEA M. WILLIAMS, J. B. Lippen-cott Company. Chicago, Philadelphia, New York. 1956. Pp. 431. \$3.20.

In reading and reviewing the chapters in *Building Health*, I found it is an excellent book for the teaching of health. It is a book that can be used by the teacher to instill proper health attitudes, and to give the student a proper insight as to what good health is. The book adequately covers many health problems that are prevalent today. With the rate of increase of mental illness, Chapters 16, 17, 18, 19, and 20 present the teacher and student material that deals adequately with this prob-

lem. This material can be used to develop proper attitudes in understanding ourselves, our relationship to other people, and the general interrelationship of society as a whole.

The sequence of material follows a logical pattern of Units which can be adapted to any course of study as set by general unit objectives. Good use is made of visual aids, and the section "On Looking Ahead" which precedes each chapter, gives all a chance to plan ahead in reading assignments, committee reports, or other activities to cover the material in the chapter. This would make an assignment more worthwhile. The "Reviewing the Chapter" section gives the students a chance to test themselves after each chapter instead of, as is customary, after the unit. In this way, if points of learning are not clear they can be reviewed. The Film Sources are pertinent and deal with material covered.

All in all the book adds up to an important and excellent book for classroom use.

Dr. Frank Casne  
Teacher—Mt. Oliver Public School  
Mt. Oliver, Pa.

### Between The Planets

- By FLETCHER G. WATSON. Revised Edition. Cambridge, Massachusetts. Harvard University Press. 1956. Pp. 188 + 67 Plates.

Teachers of general science, who lack the time or the opportunity to follow the progress of astronomy, should study this book. The general reader will find it highly informative and interesting.

The small members of the solar system; asteroids, comets, meteors and meteorites are treated adequately and interestingly. The origin, composition, and the methods used in the study of these bodies are discussed. A chapter is devoted to the use of radio waves and radar in the investigation of the solar system.

The author skillfully and accurately outlines the present status of our knowledge of these bodies. In his attempts to explain their origin he makes no purely speculative assumptions but seeks to find a theory that fits the known facts.

The printing and binding are excellent. There are fifty-three figures and sixty seven excellent photographic plates. We recommend this book for college and school libraries. J.P.M.

### The Historical Background Of Chemistry

- By HENRY M. LEICESTER. New York. John Wiley and Sons, Inc. 1956. Pp. 260. \$4.50

Too many historians of chemistry overlook the fact that chemistry is the product of man's ability to think. As a result of this oversight they have produced uninspiring narratives of dates, facts and persons. This is not true of this book.

The two outstanding features of this book are that the author concentrates on the development of chemical concepts and carefully separates the technical progress of chemistry from the growth of chemical science. The result is that *The Historical Background of Chemistry* is an easily readable and informative survey of the history of chemistry from ancient times to the present.

This book should be in the library of every chemistry department. It can serve as an excellent text-book for a brief survey-course in the history of chemistry and is suitable for listing in freshman reading lists. J.P.M.

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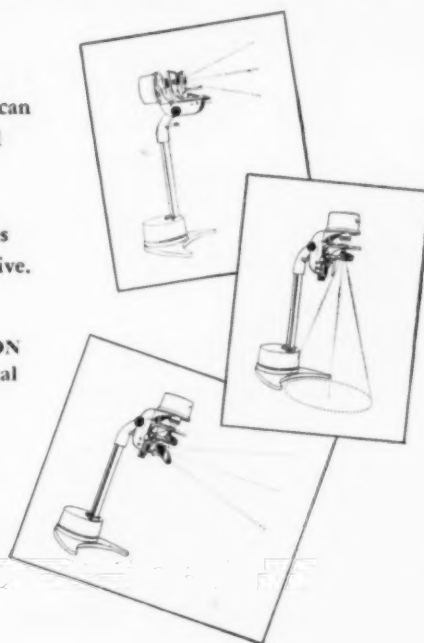
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(Continued from Page 106)

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## Malaria Statistics

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Eminent malariologists took note of these encouraging statistics at a Conference held by the World Health Organization in Athens last month. Campaigns carried out in Greece in recent years have provided scientists with much valuable knowledge on weapons being used in the fight against malaria. Success in reducing the yearly incidence of the disease has had significant effect on agricultural production, with the result that Greece now exports instead of importing rice and is practically self-supporting in wheat.

Experts felt that, with present knowledge about mosquitoes' resistance to modern insecticides, it should still be possible to eradicate malaria in European and Eastern Mediterranean areas within the next few years. Campaigns in Iran, Israel, Jordan, Lebanon and Syria, it was stated, had been transformed into all-out eradication attempts, and the WHO was coordinating efforts in adjacent countries so that these efforts would not be jeopardized. Experts recommended that the particular problem of malaria protection for nomad peoples in this region be studied by the WHO with a view to planning control measures. (UNESCO)

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